

2021 NPDES Wastewater Report

Lowell Regional Wastewater Utility



NPDES Permit Number: MA0100633

Report Date: March 31, 2022

This page intentionally left blank

Table of Contents

1.	Introduction	1
1.1	Permit History	4
1.2	Report Requirements and Layout	4
1.3	Executive Summary	4
1.3.1	Long-Term Control Plan Updates	5
1.3.2	CSO Control and Precipitation Trends in 2021	5
1.3.3	Infiltration and Inflow Reduction in 2021	5
1.3.4	Capacity, Maintenance, Operation and Management (CMOM) in 2021	6
2.	High Flow Management and CSO Control Plan and Annual Report	8
2.1	Summary Overview of Long Term CSO Control Capital Program	8
2.1.1	Phase 1 LTCP (2002-2013)	9
2.1.2	Phase 2 LTCP (2014-2021)	10
2.1.3	Phase 3 LTCP and Integrated Capital Improvements Plan	11
2.2	High Flow Management Program and Annual Report	12
2.2.1	HFM Protocol	12
2.2.2	HFM Improvement Actions in 2021	15
2.2.3	HFM Meetings	15
2.2.4	CSO Public Notification and Reporting Plan	15
2.3	Nine Minimum Controls Report	16
2.4	Precipitation, High Flow Treatment & CSO Data	20
2.5	CSO Records Certification	23
2.6	CSO Station Inspection Certification	24
2.7	SSO Notification Reporting	24
2.8	Infiltration/Inflow Control Plan and Annual Report	28
2.8.1	Introduction	28
2.8.2	Regulatory Requirements	28
2.8.3	Elements of Infiltration and Inflow Control in Lowell	31
2.8.4	Identification of Infiltration and Inflow in Lowell's Collection System	32
2.8.5	Public Infiltration/Inflow Removal	34
2.8.6	Private Inflow Control	36

2.8.7	I/I Summary for Reporting Year 2021	39
3.	CMOM Program Plan and Annual Report	43
3.1	Collection System Management	43
3.1.1	Organizational Structure	43
3.1.2	Lowell Wastewater Internal Communication	46
3.1.3	Customer Service	47
3.1.4	Management Information Systems	47
3.1.5	Sewer Surcharge Notification Program.....	49
3.1.6	Legal Authority	51
3.2	Collection System Operation	52
3.2.1	Hydrogen Sulfide Control.....	52
3.2.2	Safety	52
3.2.3	GIS Management	53
3.2.4	Lowell Property Development Review.....	57
3.2.5	Remote Stations.....	57
3.3	Equipment and Collection System Maintenance.....	59
3.3.1	Maintenance Budgeting.....	59
3.3.2	Planned and Unplanned Maintenance	59
3.3.3	Sewer Cleaning.....	60
3.3.4	Parts and Equipment Inventory	60
3.4	Sewer System Capacity Evaluation – Inspection.....	60
3.4.1	Flow Monitoring.....	60
3.4.2	Level Sensor Monitoring	61
3.4.3	Sewer System Conductance Monitoring.....	64
3.4.4	Sewer System Inspection	65
3.5	Sewer System Rehabilitation	65
3.5.1	Excavation and Replacement.....	65
3.5.2	Cured-In-Place-Pipe Lining	65
3.6	Summary of Collection System Maintenance in 2021	67
3.7	Planned Collection System Investigation/Action in 2021	72
4.	References	73

List of Tables

Table 2-1 Phase 1 LTCP Investments	10
Table 2-2 Phase 2 LTCP Investments	11
Table 2-3 Nine Minimum Controls.....	18
Table 2-4 2021 Monthly HFM Data.....	20
Table 2-5 2021 Monthly CSO Data.....	21
Table 2-6 2021 Yearly Wet-Weather Data.....	22
Table 2-7 2021 Rainfall Intensity Breakdown	23
Table 2-8 Sewer Surcharges & Overflows (2021)	26
Table 2-9 2021 Monthly Infiltration and Inflow Rates.....	41
Table 3-1 2021 Level Monitoring Summary.....	62
Table 3-2 2021 CMOM Work Log.....	68

List of Figures

Figure 1-1. Lowell Wastewater Collection and Treatment Systems Overview.....	3
Figure 2-1. Annual CSO Discharge Volumes (2005-2021)	9
Figure 2-2. Automated High Flow Management Protocol.....	144
Figure 2-3. Sewer Surcharges & Overflows (2021)	27
Figure 2-4. Conductance Survey Pilot Results.....	33
Figure 3-1. Lowell Wastewater Organizational Structure.....	45
Figure 3-2. Remote Stations Map	58
Figure 3-3. 2021 Level Sensor Locations.....	63
Figure 3-4. 2021 Conductance Surveying Results	64
Figure 3-5. 2021 CMOM Work Map.....	67
Figure 3-6. 2022 CMOM Investigation/Action Areas.....	72

1. Introduction

Lowell Wastewater is a public utility located in Lowell, Massachusetts that owns, maintains and operates a public drinking water utility; an extensive stormwater drainage system; a flood protection system; and a wastewater utility comprised by a large combined sewer system dating to the 1800s, newer separated conveyance systems, and a multi-modal wastewater treatment works that delivers efficient secondary-level treatment of dry-weather sewage flows as well as wet-weather flows up to 110 million gallons per day (MGD).

Lowell Wastewater's mission is to provide a healthy water environment in and around greater Lowell, while delivering outstanding service to the community at reasonable rates.

This Annual Clean Water Report documents and summarizes the performance of the wastewater utility in complying with its National Pollutant Discharge Elimination System (NPDES) permit under the Clean Water Act during the current reporting year. The report is inclusive of programs implemented to maintain, repair and replace the sewerage network and CSO diversion structures as well as operation and maintenance of the Duck Island Clean Water Facility (Duck Island), which operates in accordance with its NPDES permit, its voluntary ISO 14001 Environmental Management System, and all applicable state and Federal regulations.

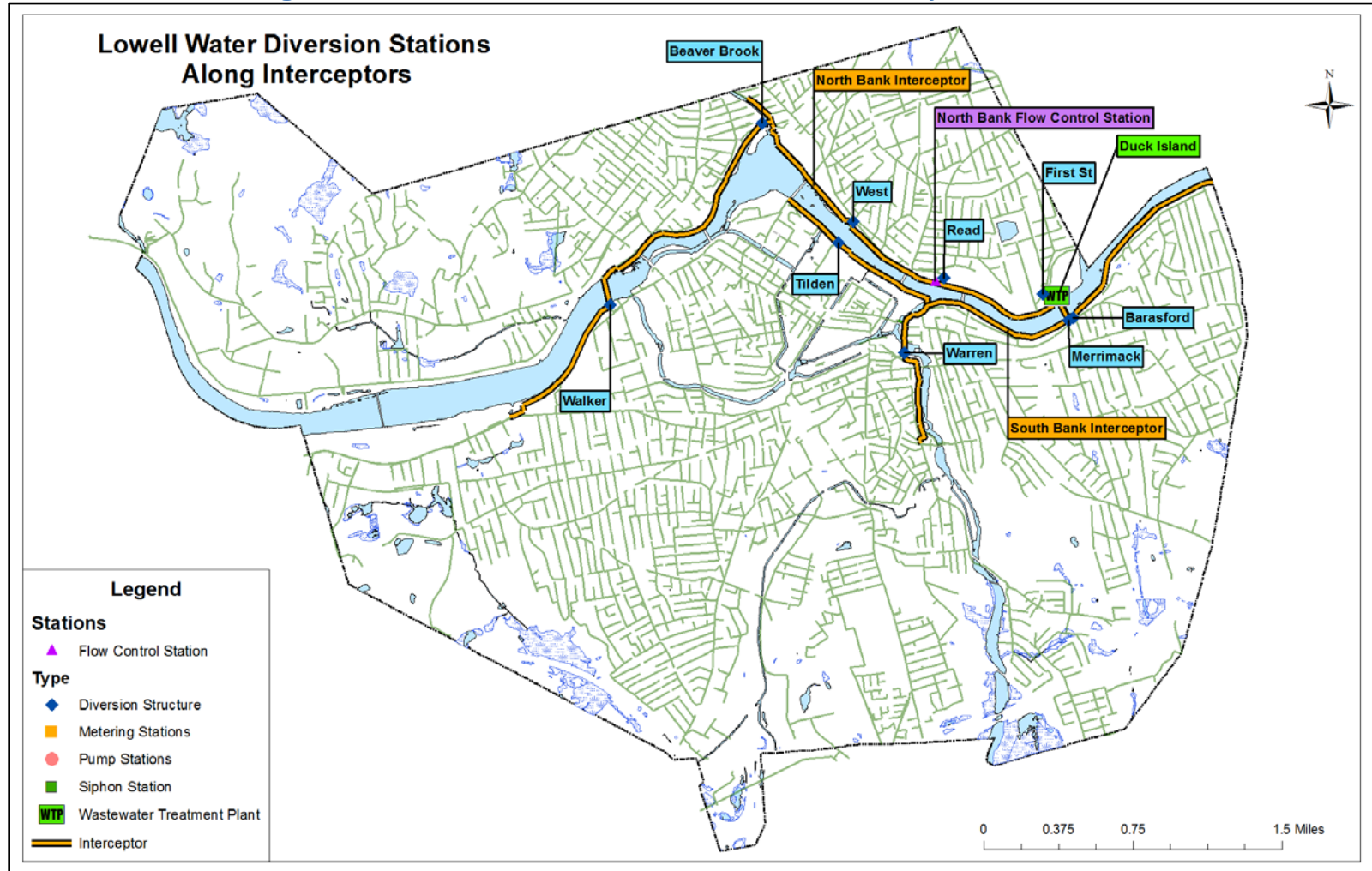
Lowell Wastewater's sewer system consists of approximately 220 miles of gravity sewers and 14 sewage pumping stations. Ten miles of large-diameter (48-inch to 120-inch) interceptors located along the banks of the Merrimack and Concord Rivers collect wastewater from the sewer system and convey it to Duck Island. Duck Island was designed to provide biological (activated sludge) treatment for an average flow of 32 million gallons per day (MGD), with a short-term peak capacity of 62 MGD. A plan view of Duck Island and the interceptor system is provided in [Figure 1-1. Lowell Wastewater Collection and Treatment Systems Overview](#), below.

During wet-weather conditions, a maximum flow of approximately 110 MGD is treated at Duck Island. Flow exceeding the capacity of the biological and secondary clarifier systems (secondary systems) causes activation of the high-flow treatment mode: high-flow treatment receives screening and clarification, which is followed by pre-chlorination before being mixed with water receiving biological treatment. This mixture is then disinfected and discharged into the Merrimack River in full compliance with secondary treatment standards.

Flow in excess of the high-flow treatment capacity is stored in the interceptor system through an automated network of gates controlled by computational algorithms designed for the purpose, and implemented in a Supervisory Control and Data Acquisition (SCADA) system. Flows to the collection system that exceed this interceptor storage capacity are diverted as combined sewer overflows (CSOs) to the Merrimack River, the Concord River and Beaver Brook, as necessary to prevent sewer system surcharges that may cause sewage back-ups into homes and streets.

Lowell Wastewater actively manages several programs vital to maintaining and operating the collection system and Duck Island effectively to implement CSO control, following the requirements outlined in its NPDES Permit at Attachment E: Nine Minimum Controls (NMC).

Figure 1-1. Lowell Wastewater Collection and Treatment Systems Overview



These programs include the following:

1. CSO Long-Term Control Plan (LTCP)
2. Collection System Capacity, Management, Operations and Maintenance Program (CMOM)
3. Combined Sewer System High-Flow Management (HFM) Program
4. Infiltration and Inflow (I/I) Control Program

This report serves as an up-to-date summary of these programs and highlights actions taken in 2021 to actively maintain and implement the NMC.

1.1 Permit History

In 2019, the United States Environmental Protection Agency (EPA) re-issued authorization to discharge under the National Pollutant Discharge Elimination System (NPDES) to the Lowell Regional Wastewater Utility (Lowell Wastewater).

NPDES Permit No. MA0100633 authorizes Lowell Wastewater to treated wastewater from its Duck Island Clean Water Facility, as well as Combined Sewer Overflows (CSOs) from nine discharge locations, into the Merrimack River, the Concord River, and Beaver Brook. The current permit became effective on August 22, 2020.

This annual report follows the reporting practices under the reissued 2019 permit.

1.2 Report Requirements and Layout

As part of the NPDES permit, Lowell Wastewater is required to submit an annual report that summarizes CSO activity and wet-weather data ([Section 2.4](#)), certifies adequate recording of CSOs ([Section 2.5](#)) and inspection of CSO facilities ([Section 2.6](#)), and reports on Lowell Wastewater's Nine Minimum Controls (NMC) program ([Section 2.3](#)).

Lowell Wastewater is also required to submit an annual report on infiltration and inflow control (I/I) activities in its sewer collection system ([Section 2.8](#)), as well as Capacity, Management, Operation, and Maintenance (CMOM) corrective actions and other activities ([Section 3](#)).

1.3 Executive Summary

This annual report is designed to meet the requirements described above, and to provide an annual record of relevant revisions to high-level planning and management of the utility. Additionally, in this 2021 report, new submittal requirements under the NPDES 2019 permit are provided, such as Lowell's CSO Public Notification Plan ([Section 2.2.4](#)).

Lowell Wastewater has continued to commit substantial resources toward reduction of CSOs, identification of inflow and infiltration, and maintenance and operation of its sewage collection and treatment systems.

Lowell Wastewater's fiscal year (FY) 2021 operating costs totaled \$25.2 million. This included funds for capital improvements and operation and maintenance of the Duck Island Wastewater Facility at \$11.9

million, and the sewerage-drainage collection systems at \$5.0 million. Each of these figures includes direct costs such as salaries, wages, services and utilities and indirect costs for services provided by other City of Lowell departments and employee overhead costs. It is worth noting, that the total operating cost also includes debt service on prior work performed under capital improvement projects and Long-Term Control Plan (LTCP) projects directed toward high-flow management and CSO control.

The primary areas of activity in 2021 are described in summary below, and the remainder of this report presents a detailed review of each program.

1.3.1 Long-Term Control Plan Updates

Details of Lowell's LTCP projects are provided in [Section 2.1](#). The Phase 3 LTCP and Integrated Planning program resulted in submission of Lowell's first Integrated Capital Improvements Program (ICIP) to MassDEP and the US EPA in December of 2019. The ICIP is now under review by these regulatory authorities and has resulted in significant progress toward identifying new system-level improvements that are expected to achieve further reduction of CSOs and improve high-flow treatment performance in the coming years. Further progress toward implementing the ICIP is contingent on regulatory approval of the plan.

Meanwhile, Lowell has continued to construct Phase 2 LTCP projects. Final completion of remote station and facility upgrades were made in 2021.

1.3.2 CSO Control and Precipitation Trends in 2021

Detailed descriptions of Lowell's High-Flow Management Program development and current practices are provided in [Section 2.2](#), and detailed annual records for 2021 are presented for review in [Section 2.4](#). Brief summary statistics for the year are provided here.

In 2021, Lowell experienced 134 days of precipitation measured at one or more of Lowell's three rain gauges distributed throughout the collection system. Total precipitation for 2021 was 52.2 inches.

This precipitation required activation of Lowell's High-Flow Treatment mode 74 times throughout the year, resulting in the successful capture and treatment of 506.5 MG of flow in excess of the biological-treatment system capacity, while still providing treatment to secondary treatment standards. CSO diversions related to these events occurred concurrently during 28 of these activations, resulting in totaled 447.5 MG in 2021. The 'capture rate', a key performance indicator defined as the ratio of treated high-flow divided by the sum of CSO discharge volume and treated high-flow, was 53% for 2021.

1.3.3 Infiltration and Inflow Reduction in 2021

Lowell Wastewater intends to submit to MassDEP an Infiltration and Inflow (I/I) Control Plan in 2021, based on specific objectives and strategies to be discussed with MassDEP.

[Section 2.8](#) of this report includes the framework for this I/I Control Plan and additionally provides a detailed review of monthly average flow rates under dry- and wet-weather conditions. This allows extrapolation of I/I estimates throughout the year.

The CMOM program continues to function as an I/I prevention program through inspection, repair and replacement of damaged sewer mains that would otherwise contribute to overall groundwater infiltration into Lowell's sewer collection system.

Lowell's Site Stormwater Management Program is a central component of I/I control efforts. By collaborating with Lowell's City Engineers and the Department of Planning and Development (DPD), Lowell Wastewater manages this program to identify opportunities for practical site improvements to control private inflow into the combined sewer system as private properties are further developed, by either reducing stormwater discharged from sites in combined catchments or requiring storage to delay the peak inflow rate into the sewer system.

In addition to the conventional metrics used to quantify infiltration and inflow (I/I) in Lowell's system, Lowell Wastewater established a pilot project in 2018 specifically designed to survey and identify primary points of entry for I/I utilizing conductance probes to screen the collection system at major junctions. This method of evaluating potential I/I sources is less expensive and may be more efficient than traditional methods utilizing flow surveys for this purpose. The pilot project identified one inflow source to the collection system in downtown Lowell where an overflow connection from the Pawtucket Canal contributed inflow into the sewer system near Market and Dutton Street. More details on this conductance-survey program are detailed in the I/I Control Plan at [Section 2.8](#).

1.3.4 Capacity, Maintenance, Operation and Management (CMOM) in 2021

Lowell Wastewater funded its CMOM program at a rate of \$5.0M in 2021, excluding debt service for capital improvements to the sewer collection system. This funding supported a variety of ongoing maintenance programs, including cleaning, inspection and repair work performed in last year:

- Replacement of 357 feet of sewer and drain line
- Repair of 2,317 feet of sewer and drain line with cured-in-place-pipe (CIPP)
- Repair and replacement of 91 catch basins
- Repair and replacement of 16 manholes
- Associated paving, test pits, and sidewalk repairs
- Cleaning of 9,395 feet of sewer and drain lines
- Video inspection of 19.7 miles (104,187 feet) of sewer and drain lines
- Handling of 397 collection-system work-order requests
- Handling of 388 catch basin, residential sewer-backup and street-flooding reports
- Bi-annual street sweeping yielding removal of 341.8 tons of sediment and debris prior to entering the collection system
- Cleaning of 540 catch basins yielding 337.5 tons of sediment and debris captured in these basins

[Section 3.6](#) includes a more detailed presentation of sewer rehabilitation work performed in 2021.

Continued opportunities for improvement to Lowell's CMOM program are discussed at bi-weekly collection-system meetings attended by multiple core staff including the Collection System Supervisor, CMMS Administrator, Drinking Water Distribution System Supervisor, City Engineers, Lowell Wastewater

Engineers, and the Executive Director of Lowell Wastewater. These meetings serve as the foundation for dissemination and discussion of institutional knowledge regarding these critical public infrastructure systems and serve as an entry point for identification of new ideas and improved procedures continually under review and assessment by Lowell Wastewater staff.

The expected identification and procurement of an advanced CMMS integrated with GIS, previously identified in the 2017 annual report, was postponed due to funding shortages related to updated capital improvement costs. Since then, Lowell has secured this funding and has hired an engineering consultant to employ an improved and integrate it with GIS

The remainder of this annual report presents the details of each of these programs in a manner intended to provide a history of development and key decisions previously made in each program. Each section of the report ends with a more detailed discussion of specific actions or opportunities for improvement identified in 2021.

2. High Flow Management and CSO Control Plan and Annual Report

This section of the 2021 Clean Water Report presents a summary of Lowell's work to date to manage high-flow events in a manner that provides effective and efficient treatment over the dynamic flow ranges experienced in our combined sewer system.

- [Section 2.1](#) summarizes past long-term control plan (LTCP) phases and coincidental capital improvement projects to the extent relevant to CSO control and the High-Flow Management (HFM) program. The present phase of work is then discussed, including a summary of progress toward completing the Phase 2 LTCP and milestones reached so far in developing the Phase 3 LTCP under the newly adopted Integrated Planning framework.
- [Section 2.2](#) summarizes the current HFM program as practiced in 2020 and discusses planned future improvements.
- [Section 2.3](#) presents the Nine Minimum Controls identified in Lowell's 2019 NPDES permit in tabular format and references the specific sections of this report that address those controls.
- [Section 2.4](#) presents annual records from Lowell's CSO monitoring and notification program.
- [Section 2.5](#) provides certification required under the NPDES permit regarding accuracy of CSO activation records presented in the previous section.
- [Section 2.6](#) provides certification required under the NPDES permit regarding CSO structures inspection and maintenance.
- [Section 2.7](#) presents a summary of unauthorized discharges that have occurred in Lowell during the past year, as well as a five year summary.
- [Section 2.8](#) presents Lowell's infiltration and inflow control plan and related actions taken in 2021.

2.1 Summary Overview of Long Term CSO Control Capital Program

Lowell has aggressively pursued a cost-effective path to reduce combined sewer overflows (CSOs) to the maximum extent practical while keeping sewer rates affordable.

Beginning in 2002, Lowell submitted its Phase I Long Term Control Plan (LTCP) for CSO control. At the start of this phase, Lowell was the largest CSO discharger on the Merrimack River, consistently discharging greater than 500 million gallons (MG) per year, and greater than 1 billion gallons in some years. Since that time, Lowell has invested more than \$120M in the CSO control measures described in the remainder of this section.

The result of these efforts is best conveyed through the trend presented in [Figure 2-1](#) below, demonstrating a reduction in overall CSO discharge volumes on the order of 80% over the period of LTCP investment.

In 2014 Lowell submitted its Phase II LTCP. After experiencing construction schedule over-runs, remaining Phase II projects were completed in 2021.

At present, the City is faced with competing needs for critical infrastructure upgrades within the City, as well as new compliance obligations related to stormwater discharges (MS4). This competition for extremely limited financial resources has led Lowell to adopt the Integrated Planning Framework

recommended by EPA to responsibly balance the financial investments needed to meet these critical stormwater, wastewater and drinking water infrastructure goals as efficiently and expediently as possible. This Integrated Planning program forms the core of the Phase 3 LTCP and is discussed in more detail, below.

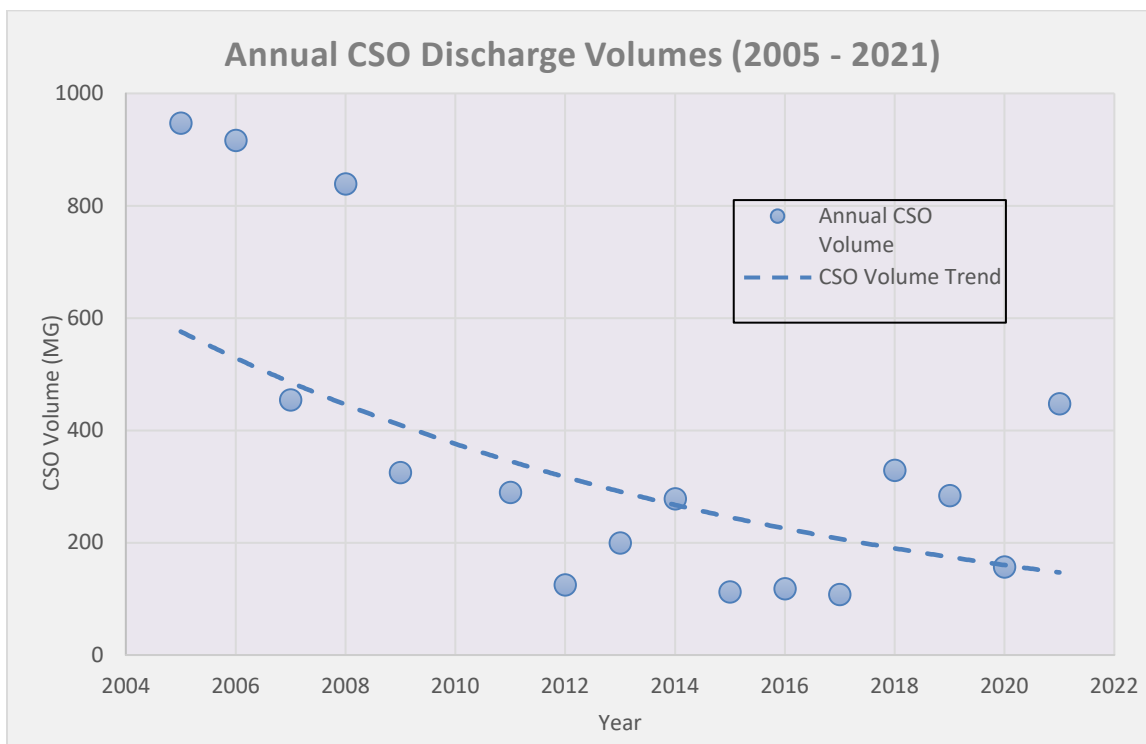


Figure 2-1. Annual CSO Discharge Volume (2005 – 2021)

The remainder of this section presents a brief summary of each phase of LTCP development and implementation to date.

2.1.1 Phase 1 LTCP (2002-2013)

In February 2002, the utility submitted its first LTCP. This LTCP identified a phased program of improvements that was developed with the intent that the city assess its ongoing implementation of the Phase 1 program to identify the benefits and determine where additional work would provide the largest environmental benefit for the least cost.

On June 16, 2003, the city received an administrative order from the U.S. Environmental Protection Agency that presented a compliance schedule for the city to implement this phased approach and move forward with the Phase 1 LTCP.

Phases planned, designed and implemented in this period included Phase 1 and sub-phases 1A, 1B and 1C, with parallel capital improvement upgrades at a total investment of \$120 million. Projects completed in this phase are summarized below.

Table 2-1 Phase 1 LTCP Investments

Project	Investment
Sewer separation	\$50 million
Wet-weather operations upgrades	\$40 million
Treatment facility process improvements and high-flow management program	\$25 million
Emergency treatment-facility upgrades	\$5 million

As the largest investment in Phase 1, Lowell's sewer separation projects resulted in 15 miles of new drainage pipes and removed public and private inflow from nearly 600 acres of combined sewer basins; another eight miles of sewer lines were rehabilitated to reduce infiltration and inflow (I/I) into Lowell's combined sewer system (CSS), at a total cost of roughly \$50 million.

Wet-weather operation investments coupled with treatment-facility process-control improvements culminated in the design and implementation of an automated High-Flow Management program (HFM) based on core principles of the NMC specified in Lowell's 2005 NPDES wastewater permit: maximizing peak flow to the treatment facility by utilizing excess primary treatment capacity, and maximizing interceptor storage.

Central to these efforts were \$4 million in upgrades to Diversion Structures intended to increase conveyance and utilize existing interceptor pipeline storage, including new control gates, instrumentation and SCADA equipment for remote operation and automated control of CSOs.

The High Flow Management Plan describing the operational procedures resulting from these improvements was submitted to EPA in 2011 and is managed as an ongoing program by Lowell staff to seek continual improvements, as detailed further in [Section 2.2](#).

Another \$7M were allocated toward treatment facility improvements at Duck Island, including gravity thickener and aeration blower upgrades that increased biological treatment capacity and performance.

Also implemented in this phase, Lowell developed and committed to an ongoing infiltration and inflow reduction program that included a sump pump disconnection program and significant investment in continual sewer rehabilitation projects throughout the City's aged infrastructure network (see [Section 3.5](#) for updates on this aspect of the Capacity, Management, Operations and Maintenance [CMOM] program).

2.1.2 Phase 2 LTCP (2014-2021)

Planning for Phase 2 began in 2012 and was finalized in 2014. As in Phase 1, an adaptive management approach was taken to target expenditures to the greatest expected return on investment, evaluate the benefits of those improvements, and adjust planned projects based on the results of previous work.

In this phase, Lowell Wastewater committed \$40 million to parallel CSO control and critical capital improvement projects. Projects totaling \$30 million directly addressed CSO control measures through capital improvements, as shown in [Table 2-2](#), below.

Table 2-2 Phase 2 LTCP Investments

Project	Investment
West Station Flood Pumping	\$4 million
Treatment facility peak-flow capacity and treatment improvements	\$16 million
Sewer relief across catchment basins to reduce surcharging	\$2.5 million
North Bank Interceptor storage	\$2 million
Sewer separation	\$2.5 million
Phase 3/Integrated Plan development	\$2 million
Green infrastructure community improvements	\$0.5 million

The Read Station Flow Control Structure, which allows additional inline wet-weather storage, was brought online in 2018. This structure is located near the Read Street diversion station, at a point where the North Bank interceptor has a significant drop from one interceptor pipe segment to the next. An actuated flow-control gate was installed upstream of this drop, in order to increase in-line storage capacity between Read and West stations. Upstream of the gate itself, a storage chamber with a capacity of approximately 0.75 MG was constructed, as well, and the site is under consideration for expansion to a screening and disinfection facility, as described in the ICIP.

Phase 2 remote station upgrades were designed to improve flow through some of the CSO diversion stations and increase reliability of communications and reporting between central SCADA servers and these stations. Substantial completion of the planned SCADA improvements was achieved in 2020, and additional programmatic cleanup work was finalized in 2021.

2.1.3 Phase 3 LTCP and Integrated Capital Improvements Plan

At present, Lowell Wastewater is working in collaboration with EPA and the Massachusetts Department of Environmental Protection (MassDEP) to develop an integrated planning program which will follow the EPA Integrated Planning Framework, as discussed above. While it is expected that this approach will allow Lowell to balance CSO control investments with other infrastructure needs, like stormwater control and drinking water reliability, Lowell remains committed to reducing CSOs through effective control strategies as quickly as possible. The Integrated Capital Improvements Plan (ICIP) was submitted in December 2019; EPA and MassDEP have since reviewed the ICIP and provided feedback to Lowell in Q1 2022.

As has been discussed above, Lowell's investments in CSO control to date have focused primarily on optimizing the use of existing infrastructure prior to investing in new infrastructure, whether that may be in the form of separate drainage systems, additional storage capacity, or wet-weather treatment. This approach has been aligned with meeting the requirements in Lowell's 2019 NPDES permit to maximize flow to the treatment facility through use of excess primary clarifier capacity and to maximize storage in the collection system prior to allowing diversions to occur.

Initial review of the flow-metering data and the model simulation results suggests that Lowell has approached the maximum limit for utilization of its existing infrastructure to control CSOs. Achieving this goal was considered the first logical step during the Phase 1 LTCP, and now that it has been largely

attained, the focus will shift to assessment of new infrastructure options to eliminate the ‘remaining’ CSO discharges relative to pre-control levels of discharge.

As an example, it was previously mentioned that the Read Street flow-control structure may be exceptionally well suited for design of a wet-weather facility that would provide screening and disinfection of wet-weather flows. The benefit of such a facility, in terms of annual untreated CSO discharge reduction, has been estimated to be on the order of 50% reduction of total untreated CSO volume in a ‘typical year’ identified for the model simulation baseline. Such a control strategy would allow for rapid improvement to the water quality downstream of Lowell, in a manner consistent with practices established by other Merrimack River communities (e.g., Nashua, NH).

Empirical support for this control strategy from a water-quality perspective was established in 2018 through Lowell’s water-quality monitoring program (*Clean Stream Initiative*), which collected in-stream bacteria (*E. coli*) concentration data during and for several days after storm events which activated the similarly designed Nashua wet-weather facility. Throughout these sampling periods, upstream water quality did not violate the single-sample maximum bacteria criteria.

2.2 High Flow Management Program and Annual Report

Lowell Wastewater’s High Flow Management program (HFM) has been developed to maximize the treatment and storage of wet-weather flows with existing infrastructure prior to investing in planning and construction of new infrastructure. This program’s conceptual groundwork lies in the Nine Minimum Controls (Part I.F.2(a) of Lowell’s 2019 NPDES wastewater permit), wherein it is explicitly stated that Lowell should maximize flow to the treatment plant through the utilization of excess primary treatment capacity and maximization of the existing collection system for in-line storage. Accordingly, and as described above, Lowell has invested heavily in developing this program over the past two decades.

This section of the report provides a detailed presentation of the current HFM protocol as practiced in 2021.

2.2.1 HFM Protocol

Lowell Wastewater developed and implemented a Supervisory Control and Data Acquisition (SCADA) network, which allows operators to remotely control and monitor gates, valves, and pumps directly from the Operations Center at Duck Island. In addition to equipment at Duck Island, remote monitoring and control was enabled at eight active CSO diversion stations along the interceptor system. Lowell Wastewater has developed automated wet-weather protocols implemented through algorithms.

The HFM protocol follows the logic:

1. Maximize flow to the Duck Island treatment facility
2. Maximize use of available storage in the collection system’s interceptors upstream of flow-control gates
3. Prevent sewer surcharging by diverting flow through CSO stations

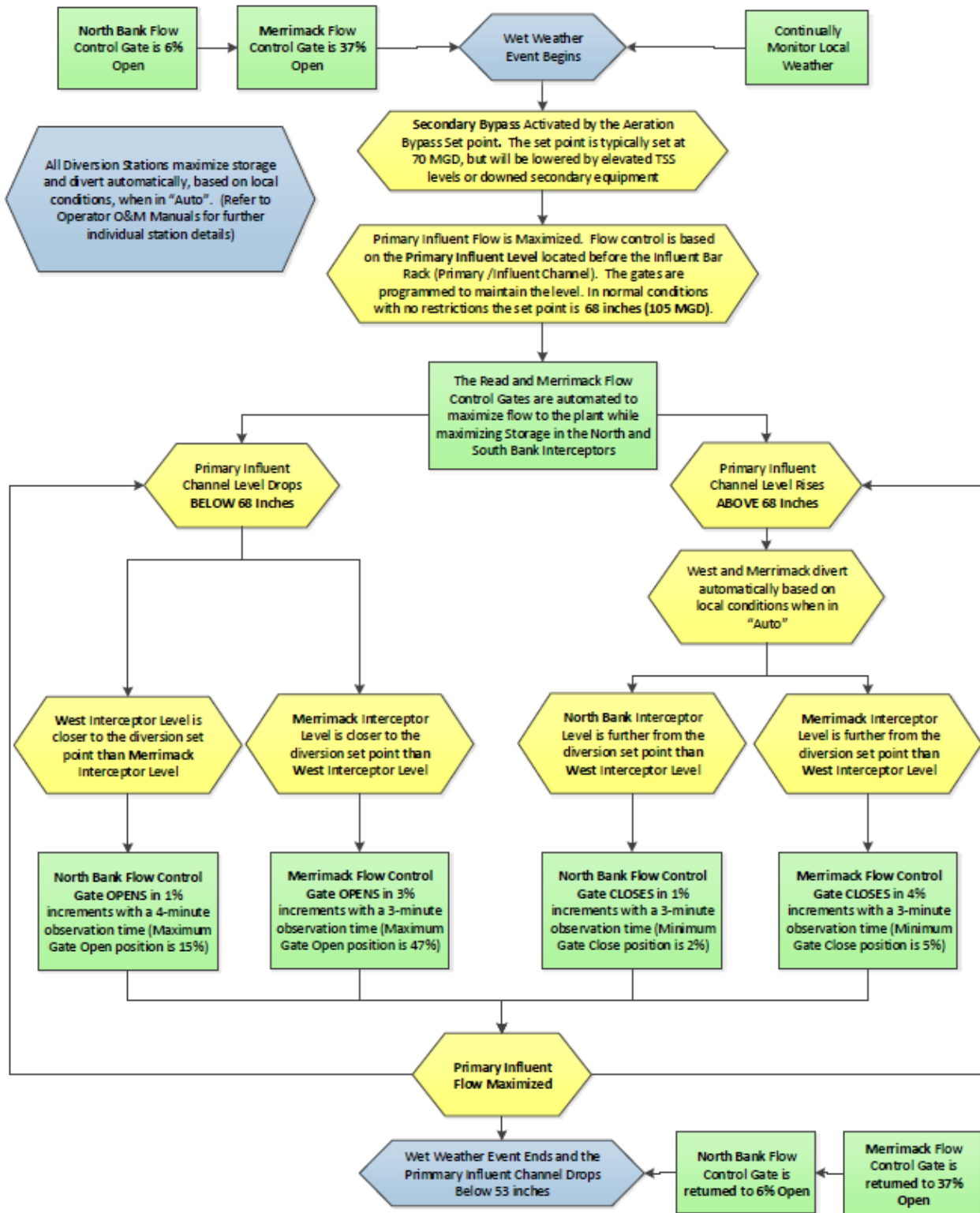
With a bit more detail, the North Bank and South Bank interceptors are controlled primarily by gates at Read Station (on the North Bank) and at Merrimack Station (on the South Bank). These gates are kept open to levels that do not restrict flow under normal (dry) conditions. Upon the start of a wet-weather event, these gates are set to allow free gravity flow to the facility until the Duck Island treatment facility has reached maximum capacity (this is a variable range dependent on process performance and external factors, but generally lies within 96-112 MGD).

Upon maximization of flow to the biological treatment system, the secondary bypass gates are opened to allow excess primary treatment capacity to be conveyed to the outlet of the secondary clarifiers. The hydraulic capacity at Duck Island is currently restricted to an instantaneous peak flow rate of 110 MGD, and an average hourly flow rate of 105 MGD. Flows in excess of this upper limit are not allowed, and so result in the Read Station and Merrimack Station control gates modulating to maintain the maximum flow rate to Duck Island. As these gates modulate, levels in the interceptor rise until they reach the diversion set point. Upon crossing this threshold, excess flows are diverted through CSO stations to prevent sewer surcharging.

At present, chlorine pumps are installed for manual dosing of the secondary bypass line to allow for disinfection of the primary effluent. High-flow treatment continues in this manner until the plant-influent flow rate falls below the biological treatment capacity, whereupon the secondary bypass gates are closed.

Figure 2-2, below, provides a visual representation of the HFM protocol, as followed at present.

Figure 2-2. Automated High Flow Management Protocol



2.2.2 HFM Improvement Actions in 2021

The following actions have been undertaken to inform improvements to the HFM program in 2021.

SCADA Upgrades

The SCADA system that serves as the core architecture for the HFM Plan is continuously being optimized to improve communications, reliability and overall security.

High Flow Management Plan Update

Lowell Wastewater engineering staff began a station-by-station review of measurements taken at CSO stations that factor into HFM automation protocols. These measurements were originally developed in 2009-2011 by Lowell staff and CDM, during the initial design of the HFM program. Lowell continues to review and refine its HFM Plan to reflect improved performance capabilities brought on by system upgrades

As this review process continues, the HFM plan will be revised and updated to reflect the current system state.

2.2.3 HFM Meetings

Central to the HFM program is a recurring bi-weekly meeting at which Lowell Wastewater staff from the Operations, Maintenance and Engineering divisions convene with the Executive Director to discuss recent high-flow events and assess performance of those events. Recurring action items include review of gate positions, system levels and flows, and precipitation records to assess opportunities for improvement; review of plant discharge sampling data to ensure that treatment levels meet permit limits; review of any CSO/wet-weather data anomalies as described in [Section 2.5](#); status updates on SCADA improvements and previously identified opportunities for improvement.

2.2.4 CSO Public Notification and Reporting Plan

Since 2018, Lowell has provided near real-time notification of CSO discharges to interested parties via emails sent by Operations staff as they occur. Detailed reports of each CSO event and High-Flow Treatment performance are sent to all parties after proper validation of instrument and communication records within ten days of the end of a high-flow or CSO event. Lowell has also designed more ‘readable’ notification reports in response to concerns presented by downstream community representatives that standard reporting formats were difficult to understand.

Interested individuals may request admission to Lowell Wastewater’s CSO notification list at any time by filling out a CSO Notification Request web form that is accessible from the utility’s department page on the City’s website (lowellma.gov). Upon completion, an automated email is sent to appropriate engineering staff who then append the provided email address to Lowell Wastewater’s CSO notification list. Individuals may also opt to provide their phone number as a preferred means of notification, however, the detailed reports are only shared via email.

Lowell engineering staff have been actively involved in communication and collaboration with special interest groups like the Massachusetts Coalition for Water Resources Stewardship, Massachusetts Rivers Alliance, the Massachusetts Municipal Stormwater Coalition, the Merrimack River Watershed Council, the

Northern Middlesex Council of Governments and others to identify the primary objectives of public notifications that may be delivered in a timeframe manageable from a utility perspective while still meaningful to the general public. Lowell continued to engage in this public outreach project in 2021.

Many of these voluntary standard procedures were stated as requirements in Lowell's 2019 NPDES permit, which requires submittal of a public notification plan (provided herein). Specific requirements of the 2019 permit include (at Part I.F.3(g)):

- Initial notification, to be provided no later than four hours after becoming aware by monitoring, modeling or other means, and to include the date and time of probable CSO discharge, CSO [outfall] number and location.
- Supplemental notification, to be provided within 24 hours after becoming aware of the termination of a CSO discharge, and to include the CSO [outfall] number and location, confirmation of the CSO discharge, and the CSO date, start and stop time.
- Annual notification, to be submitted by March 31, and to include the number of CSO activations and volume of each, status and progress of CSO abatement work, and contacts for additional information on CSOs and water quality impacts on a website.

Lowell's CSO Public Notification Plan is as follows:

1. Continuous monitoring of CSO discharges at all permitted CSO outfalls through the SCADA network.
2. Initial notification to all subscribers via email and/or text message within four hours of the start of a CSO discharge.
3. Supplemental notification is provided within four hours of the termination of CSO discharges to all subscribers. This message includes the date and time at which the CSO discharges ceased.
4. Full report provided within 10 days showing each station's hourly discharge duration and volume, including rainfall and high-flow treatment performance metrics.
5. Quarterly summaries of all wet-weather events are posted online.
6. Annual summary of all wet-weather events is posted online and included in Lowell's Annual Wastewater Report ([Section 2.4](#)).

2.3 Nine Minimum Controls Report

The Nine Minimum Controls (NMC) are stipulated in Lowell's 2019 NPDES permit (at Part I.F.3.(a)). EPA states therein that EPA has made a Best Professional Judgment (BPJ) determination that adequate implementation of these nine minimum control measures satisfies technology based requirements (Best Practicable Control Technology Currently Available (BPT), Best Conventional Pollutant Control Technology (BCT)) to control and abate conventional pollutants and Best Available Technology Economically Achievable (BAT) to control and abate non-conventional toxic pollutants.

Given this BPJ on the part of EPA, Lowell Wastewater has invested heavily in the NMC technologies, as detailed in this section and elsewhere in this report. [Table 2-3](#) details the documentation required by EPA to demonstrate: 1) that alternatives were considered for each of the nine minimum control measures, 2)

the reasoning for the alternatives selected, 3) that the selected alternatives have been implemented, and 4) that the permittee has developed a schedule for actions that have been selected but not yet fully implemented.

The remainder of this section discusses Lowell's work to date toward implementing the NMCs as practicable. Where a particular control is covered in detail in another section of this report, the reader is referred to that section for more information.

Table 2-3 Nine Minimum Controls

Control	Documentation Requirements	Reported At/Details
1. Proper operation and regular maintenance programs for the sewer system and combined sewer overflow points	<ul style="list-style-type: none"> a. Organizational O&M responsibilities chart b. Funding allocated for O&M c. List of critical facilities and structures (regulators, tide gates, pumping stations, sections of sewer lines prone to sedimentation or obstruction) and inspection plan (locations, frequency, procedures, documentation, reporting of periodic and emergency inspections and maintenance) 	<ul style="list-style-type: none"> a. Section 3.1.1 b. Section 1.3 c. Section 3.2.8
2. Maximize Use of the Collection System for Storage	<ul style="list-style-type: none"> a. Identification of maintenance or design deficiencies that restrict the use of otherwise available system capacity b. Adequacy of tide gate maintenance and repair procedures c. Document the method for optimal setting of regulators d. Document procedures for identification and removal of obstructions to flow. Include a summary of the locations where sediment is removed, the number of times each year the sediment is removed and the total quantity of material removed each year 	<ul style="list-style-type: none"> a. Section 3.4 b. Section 2.6 c. Section 2.2 d. Section 3.3.3 and Section 3.4.3
3. Review and modification of the Industrial Pretreatment Program (IPP) to assure CSO impacts are minimized	<ul style="list-style-type: none"> a. Review legal authority and identify those activities for which the community has or can obtain authority to address CSO induced water quality violations (e.g., authority to require non-domestic dischargers to store wastewater during precipitation events or require them to implement runoff controls) b. Inventory non-domestic dischargers that may contribute to CSO induced water-quality violations c. Assess whether identified dischargers cause or contribute to CSO induced water-quality violations by using monitoring, dilution calculations or other reasonable methods d. Evaluate and propose feasible site-specific modifications to address non-domestic dischargers identified as significant 	See Annual Pretreatment Report, submitted separately by Lowell Wastewater's Pretreatment Coordinator at present.
4. Maximization of flow to the treatment facility	Evaluate and implement where possible: <ul style="list-style-type: none"> a. Use of off-line or unused POTW capacity for storage of wet-weather flows b. Use of excess primary treatment for treatment of wet-weather flows. If the use of excess primary capacity will result in violations of the NPDES permit limits, the community shall get approval from the permitting authority prior to implementation 	Section 2.1 (history) and Section 2.2 (current practice)
5. Prohibition of CSO discharges during dry weather	<ul style="list-style-type: none"> a. Document that monitoring and inspections are adequate to detect and correct dry-weather overflows (DWOs) in a timely manner b. Document that inadequate DWOs due to inadequate sewer system capacity have been eliminated c. Document that DWOs due to clogging of pipes and regulators or other maintenance problems have been eliminated to the maximum extent practicable 	<ul style="list-style-type: none"> a. Section 2.2 b. Section 2.4 c. Section 2.4
6. Control of solid and floatable material in CSO Discharges	Document that low-cost control measures to reduce solids and floatables discharged from CSOs have been implemented to the maximum extent practicable. Alternatives shall include: <ul style="list-style-type: none"> a. Baffles in regulators or overflow structures b. Trash racks in CSO discharge structures c. Static screens in CSO discharge structures d. Catch basin modifications 	Street sweeping is implemented bi-annually throughout Lowell, which serves to reduce the amount of litter washed into the collection system. Catch basins have hoods to minimize the amount of floatables leaving the basin, and are deep-sumped to minimize the amount of solids leaving the basin. Further opportunities will be explored to further reduce discharge of solids and floatables from CSO outfalls in Lowell. More details at Section 3.3.3

Table 2-3 Nine Minimum Controls

Control	Documentation Requirements	Reported At/Details
7. Pollution prevention programs that focus on contaminant reduction activities	<ul style="list-style-type: none"> a. Prevention through increased public education and awareness b. Control of disposal (garbage receptacles, collection and education) c. Control of illegal dumping (law enforcement, public education, disposal programs) d. Street cleaning e. Hazardous waste collection days 	<ul style="list-style-type: none"> a. Lowell's website was revised in 2019 to include visual graphics depicting how the <i>collection</i> and <i>treatment</i> systems operate, and how they can take actions to reduce impacts on operations and maintenance. b. Hazardous waste collection days are held regularly at Duck Island and other programs are actively managed by the City's Solid Waste and Recycling Office, which also manages a public radio program addressing this subject. c. Lowell Wastewater supports a catch basin labeling program to notify residents not to dispose of wastes in these receptacles. d. Section 3.3.3 e. Addressed at (b)
8. Public notification to ensure that the public receives adequate notification of CSO occurrences and CSO impacts	<ul style="list-style-type: none"> a. Ensure that the public receives adequate notification of CSO impacts on pertinent water use areas, particularly beach and recreational areas affected b. Where applicable, provide users of these types of areas with a reasonable opportunity to inform themselves of the potential health risks c. The minimum control level, found in Section C.2.e. of the permit, is posting of CSO discharge points 	CSO Public Notification and Reporting Plan 2.2.4
9. Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls	<ul style="list-style-type: none"> a. If possible, initiate monitoring and/or inspection activities above and beyond the minimum control levels specified in this permit b. Examples include CSO monitoring or receiving water monitoring for pollutants of particular concern to better characterize quality of the CSOs and their impacts on all receiving waters 	<p>Lowell contributed matching funds to the US Army Corps of Engineers (USACE) <i>Merrimack River Watershed Assessment Study</i>, which conducted extensive water-quality monitoring and modeling tasks from 2003-2018. This study is now complete and a final report is forthcoming from USACE.</p> <p>Additionally, Lowell Wastewater carried out extensive wet-weather CSO and receiving water monitoring in 2018 and has shared this data with the Merrimack River Watershed Council, Merrimack River District Commission, MassDEP and US EPA.</p> <p>In 2019, Lowell purchased a <i>Fluidion</i> ALERT system, which has been used extensively in Europe to improve monitoring of in-stream water-quality impacts of CSOs. In 2021, Lowell upgraded to the <i>Fluidion</i> ALERT V2 system. This model features improved system performance with respect to analytical accuracy and battery performance, allowing for longer deployments that result in more reliable data. Lowell plans to continue utilizing the <i>Fluidion</i> ALERT V2 system for monthly deployment in 2022.</p>

2.4 Precipitation, High Flow Treatment & CSO Data

Table 2-4. 2021 Monthly HFM Data

Date	Clean Water Discharge		Duck Island Rain		Treated High Flow			All Diversions		
	Flow (MG)	Peak Hour (MGD)	Rain Days	Rain Inches	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)
Jan 2021	206	106.3	6	2.4	2	20.7	18.4	1	4.9	16.86
Feb 2021	289	104.1	11	2.2	1	5.1	9.5	-	-	-
Mar 2021	244	72.4	7	1.9	4	11.3	6.3	-	-	-
Apr 2021	392	97.5	10	6.7	7	45.5	53.6	2	13.3	86.52
May 2021	605	100.9	15	5.4	11	73.3	80.0	2	4.4	13.39
Jun 2021	288	94.4	10	1.9	4	13.4	13.6	1	0.6	2.17
Jul 2021	909	109.6	22	9.3	15	86.4	118.2	7	14.4	145.32
Aug 2021	320	105.0	9	4.4	8	34.2	47.0	3	3.0	37.09
Sep 2021	456	112.1	12	5.8	6	35.9	54.4	5	8.7	92.74
Oct 2021	427	109.1	10	6.3	7	54.6	72.2	5	8.4	20.56
Nov 2021	269	103.1	8	2.5	3	12.3	13.9	1	3.0	31.65
Dec 2021	452	91.7	14	3.5	6	18.4	19.4	1	0.7	1.16
Total	4,846	1,206.1	134	52.3	74	411.0	506.5	28	61.2	447.5
Max	909	112.1	22	9.3	15	86.4	118.2	7	14.4	145.3

Table 2-5 2021 Monthly CSO Data

Date	Barasford Street			Beaver Brook			Merrimack Street			Read Street			Tilden Street			Walker Street			Warren Street			West Street		
	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)
Jan 2021	1	3.5	4.77	1	0.7	0.05	1	4.9	7.33	-	-	-	1	2.8	0.43	-	-	-	1	0.6	0.28	1	2.2	4.00
Feb 2021	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mar 2021	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apr 2021	1	9.8	15.54	1	2.7	1.50	1	9.1	14.25	-	-	-	1	5.4	3.54	1	2.6	4.22	1	3.3	13.57	2	13.3	33.90
May 2021	1	2.6	3.49	1	0.6	0.13	1	2.3	3.22	-	-	-	1	1.3	0.43	-	-	-	1	0.6	0.72	2	4.4	5.40
Jun 2021	-	-	-	-	-	-	-	-	-	-	-	-	1	0.2	0.03	-	-	-	1	0.6	2.14	-	-	-
Jul 2021	4	6.5	9.67	5	7.0	11.79	6	11.6	21.50	-	-	-	6	10.4	11.99	5	5.4	13.51	5	7.5	30.36	6	14.4	46.50
Aug 2021	1	1.4	2.26	2	1.6	3.36	3	3.0	7.12	-	-	-	2	2.9	3.02	1	1.3	4.16	2	2.1	10.77	2	1.5	6.40
Sep 2021	3	7.5	10.24	5	6.3	7.02	3	7.7	16.34	1	0.1	0.02	5	7.7	7.01	2	4.0	5.58	3	6.1	16.53	3	8.7	30.00
Oct 2021	3	2.9	4.03	1	0.4	0.12	3	5.0	5.06	-	-	-	4	1.5	0.72	-	-	-	1	0.6	0.63	3	8.4	10.00
Nov 2021	1	0.8	1.55	1	1.1	2.23	1	2.1	4.88	-	-	-	1	1.3	2.24	1	1.1	3.68	1	1.3	9.27	1	3.0	7.80
Dec 2021	-	-	-	1	0.2	0.15	1	0.7	0.77	-	-	-	1	0.4	0.06	-	-	-	1	0.3	0.28	-	-	-
Total	15	34.9	51.55	18	20.6	26.25	20	46.4	80.47	1	0.1	0.02	23	33.7	29.47	10	14.4	31.15	17	22.8	84.55	20	55.8	144.00
Max	4	9.8	15.54	5	7.0	11.79	6	11.6	21.50	1	0.1	0.02	6	10.4	11.99	5	5.4	13.51	5	7.5	30.36	6	14.4	46.50

Table 2-6 2021 Yearly Wet-Weather Data

See Table on Following Page

Lowell Wastewater Utility
Yearly Wet-Weather Data
January 01, 2021 - December 31, 2021

[illegible]

Date	Duck Island Precipitation					Clean Water Discharge			Treated High Flow			Barasford Street			Beaver Brook			Merrimack Street			Read Street			Tilden Street			Walker Street			Warren Street			West Street			All Diversions		
01/01/21 12/31/21	Precip Days (No.)	Daily Total (Inches)	Peak Hour (Inches)	Event Peak hour (Inches)	Flow (MG)	Peak Hour (MGD)	Event Peak (MGD)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	
10/3/2021	1	0.13	0.09		23.21	32.97																																
10/4/2021	1	1.60	0.22	0.22	60.08	109.14	109.14	1	14.22	18.88													1	0.17	0.10							1	0.17	0.10				
10/5/2021	1	0.33	0.16	0.16	49.42	99.08	99.08	1	6.73	9.96	1	0.55	0.68				1	1.37	1.17											1	2.63	3.10	1	2.63	4.95			
10/16/2021	1	0.03	0.03		24.12	34.38																																
10/17/2021	1	0.29	0.10		31.12	50.66																																
10/25/2021	1	0.50	0.13		32.15	58.81		1	0.80	0.33																												
10/26/2021	1	1.24	0.22	0.22	54.92	100.52	100.52	1	12.80	11.51													1	0.08	0.05							1	0.08	0.05				
10/27/2021	1	0.35	0.08		39.49	57.54		1	0.97	0.38																												
10/30/2021	1	1.17	0.33	0.33	43.17	103.11	103.11	1	4.70	9.67	1	1.65	2.34	1	0.42	0.12	1	2.22	2.43				1	0.93	0.41					1	0.55	0.63	1	3.85	4.40	1	3.85	10.33
10/31/2021	1	0.64	0.20	0.20	69.17	101.59	101.59	1	14.33	21.48	1	0.67	1.01	1			1	1.42	1.46				1	0.28	0.16					1	1.88	2.50	1	1.88	5.13			
11/12/2021	1	1.55	0.74	0.74	49.82	103.11	103.11	1	8.75	12.44	1	0.83	1.55	1	1.10	2.23	1	2.05	4.88				1	1.30	2.24	1	1.07	3.68	1	1.25	9.27	1	2.95	7.80	1	2.95	31.65	
11/13/2021	1	0.21	0.11		36.32	50.80		1	1.22	0.26																												
11/15/2021	1	0.07	0.03		32.72	38.97																																
11/18/2021	1	0.02	0.02		28.80	37.17																																
11/19/2021	1	0.20	0.13		32.94	56.23		1	2.37	1.19																												
11/21/2021	1	0.12	0.04		29.48	42.69																																
11/22/2021	1	0.09	0.03		31.22	42.46																																
11/26/2021	1	0.21	0.03		28.15	40.59																																
12/2/2021	1	0.09	0.03		26.21	37.66																																
12/6/2021	1	0.23	0.12		28.34	69.99		1	2.05	1.27																												
12/11/2021	1	0.77	0.28	0.28	38.37	91.71	91.71	1	5.32	9.03				1	0.15	0.05	1	0.72	0.77																			
12/12/2021					32.55	86.35		1	2.37	2.45																												
12/15/2021	1	0.05	0.04		24.09	32.18																																
12/16/2021	1	0.22	0.06		29.92	48.63																																
12/17/2021	1	0.35	0.18		24.01	30.93																																
12/18/2021	1	0.51	0.09		28.27	54.79		1	0.38	0.12																												
12/19/2021	1	0.28	0.08		38.97	78.58		1	4.10	3.05																												
12/22/2021	1	0.25	0.07		32.38	56.48																																
12/25/2021	1	0.37	0.14		33.50	75.75		1	4.17	3.49																												
12/26/2021	1	0.29	0.07		35.17	51.91																																
12/28/2021	1	0.04	0.03		27.45	35.28																																
12/30/2021	1	0.02	0.02		26.40	34.06																																
12/31/2021	1	0.02	0.01		26.09	35.27																																
Date	Duck Island Precipitation					Clean Water Discharge			Treated High Flow			Barasford Street			Beaver Brook			Merrimack Street			Read Street			Tilden Street			Walker Street			Warren Street			West Street			All Diversions		
No. Days	Precip Days (No.)	Daily Total (Inches)	Peak Hour (Inches)	Event Peak (Inches)	Flow (MG)	Peak Hour (MGD)	Event Peak (MGD)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	Event (No.)	Duration (Hours)	Volume (MG)	
137																																						
Total/Max	134	52.20	0.86	0.86	4,845.90	112.05	112.05	74	410.98	506.52	15	34.90	51.55	18	20.55	26.25	20	46.35	80.47	1	0.08	0.02	23	33.65	29.47	10	14.38	31.15	17	22.80	84.55	20	55.80	144.00	28	64.03	447.46	

Note: This table is a summary of data occurring on days in which the Duck Island rain gauge recorded rainfall and/or the facility discharged treated high flow related to wet-weather activity.

2.5 CSO Records Certification

All data from High-Flow Treatment and CSO events are reviewed by Lowell Wastewater staff during the 10-day validation period following the event. This review process is critical to ensuring accurate representation to the public regarding collection system and treatment plant performance during such events. Electronic instruments are installed at key points throughout the collection system and calculations are automated via Lowell's SCADA system to streamline this process, but these instruments and the SCADA system itself are prone to both machine and human error at times – most notably during storm events, when communications may be lost due to atmospheric interference, high river levels may invalidate the assumptions of some of the automated calculations, and instruments may become impaired by debris or other malfunctions may occur.

This review process entails a detailed review of SCADA instrument records and, where necessary, recalculation of discharge volumes using external programs developed to consider infrequent but relevant flow conditions such as backwater effects from high river levels.

Following this review process, final reports are issued to the public. Such review processes occasionally uncover a previously unknown error in the calculation of CSO volumes. No significant errors were observed in 2021.

The final record of CSO discharge volumes is presented in [Section 2.4](#), and is hereby certified by Lowell Engineering staff as a true and accurate estimation of all CSO discharges from Lowell's permitted outfalls in 2021. These records are stored at Duck Island in Lowell's Water Information Management System (WIMS).

CSO Assessment for 2021

Lowell saw a large increase in CSO volume discharge during 2021. This higher volume is largely the result an increase in frequency and intensity of the rain events experienced during this calendar year; a fact that is largely attributable to climate change.

[Table 2-7](#) below provides a breakdown of the yearly rainfall in Lowell for 2021, and a comparison to previous years' data. This data reflects that not only did Lowell receive a larger total volume of rainfall, but also an increase in days with larger volumes of rain in 2021 than in years past.

Table 2-7. 2021 Rainfall Intensity Breakdown

Year	Tot. Rain (in.)	CSO Vol. (MG)	Rain Days	Days > 0.5 in.	Days > 1.0 in.	Days > 1.5 in.	Days > 2.0 in.
2021	52.2	447.5	134	39	18	8	3
2020	44.4	156.8	144	26	11	5	2
2019	43.3	284.5	158	37	13	2	0

Of the 447.8 MG of CSO volume discharged in 2021, 233.5 MG of this volume came from only three of the total 28 CSO events. This can be interpreted as 52% of Lowell's total CSO discharge for 2021 coming from only 11% of the total discharge events for the year.

Beyond these three large storms, Lowell experienced three more storms with CSO volumes in the 30 to 40 MG range in 2021. For each of these storms rainfall was between 1.4 and 1.55 inches and the treated plant flow averaged 56.65 MG. The peak hourly flow at Duck Island for each storm was above 100 MGD. Beyond these six storms the next largest volume of CSO recorded in 2021 was 16.86 MG.

2.6 CSO Station Inspection Certification

CSO structures are inspected regularly by maintenance personnel on the Structures Crew. The Structures Crew visits all remote/satellite stations on a daily basis, all inspection records are collected digitally and managed by Lowell Wastewater's engineering staff.

CSO diversion stations are inspected weekly by the same personnel. Structures are inspected to verify that the grounds are clear and accessible, including any need for landscaping services; record wet-well conditions (normal, flooded, evidence of flooding, high wet-well level); HVAC systems, lighting, and SCADA systems are functional; and perform basic cleaning tasks.

In 2019, an additional task was added to each inspection to ensure frequent (weekly) visual inspection of each associated CSO outfall for evidence of dry-weather discharge. Records of these visual inspections are documented using do-Form checklists unique to each station. The do-Forms are designed to host streamlined single-choice questions that guide recording personnel through the inspection. If a submitted inspection form contains any anomalous or concerning answers, an automatic alert is triggered and distributed to the Operations Manager, Maintenance Manager and Maintenance Supervisor for review.

In 2021, all CSO structures were routinely inspected; observed issues are logged into the MP2 work-order system and/or discussed at the bi-weekly collection system meetings, as necessary.

2.7 SSO Notification Reporting

Sewer Surcharges & Overflows in Lowell (2021)

A review of Lowell's SSO Notification reports, used to report both sanitary (separate) sewer overflows and overflows due to combined sewer surcharges, was conducted in 2021. [Table 2-8](#), below, presents these events and associated details including type of overflow (combined (CSO) or separate (SSO)), date, estimated volume, where the sewage was discharged to (e.g., residential property/basement, ground/street surface, receiving water), root cause, and corrective actions taken to resolve the cause of the surcharge/overflow. Surcharges assessed to be the result of inadequate system capacity are shaded orange for emphasis.

[Figure 2-3](#) displays these events on a map of Lowell. Callout boxes identify those locations listed in [Table 2-8](#) and the corresponding corrective action taken. Lowell experienced ten sewer surcharges in 2021: one occurred in a separated sewer line, while the remaining nine occurred in combined areas of the collection system.

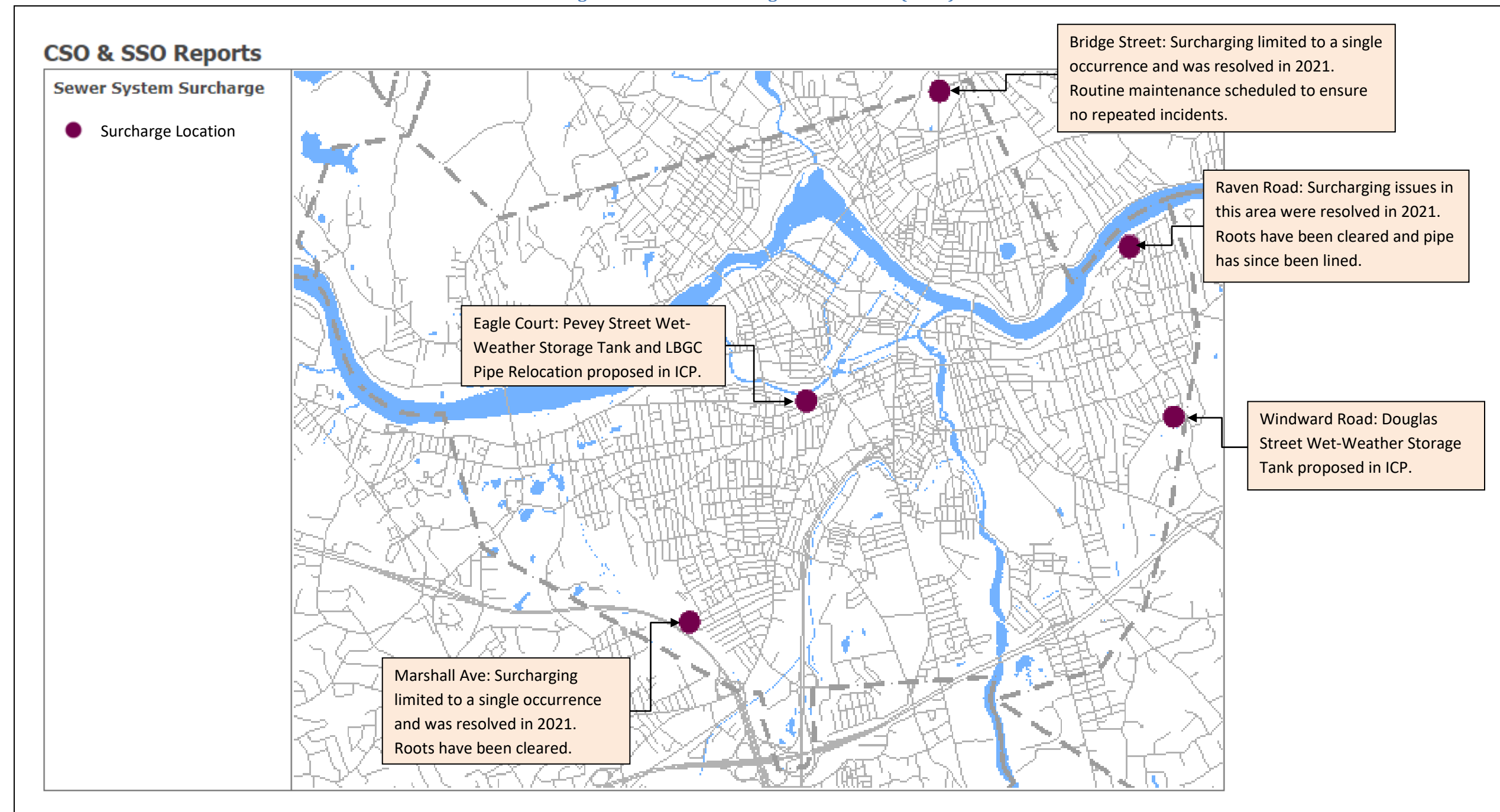
It should be noted that only one sanitary sewer overflow was observed in the 2021. This SSO was caused by root intrusion within the pipe, which has since been cleared. The only other sanitary sewer overflow to occur within the past five years was associated with a construction project bypass. In both instances,

traditional I/I was not a factor in causing these overflows. This is important evidence supporting Lowell's position that infiltration is not contributing significantly to such overflows.

Table 2-8. Sewer Surcharges & Overflows (2021)

Surcharge Type	Date	Discharge From	Discharge To	Associated Address	Estimated Volume (Gal)	Cause	Comments	Corrective Actions Taken
CSO	4/1/2021	Combined Sewer Manhole	Ground	1230 Bridge St.	50	Other	Partial flume blockage	Flume blockage was removed.
SSO	5/24/2021	Sanitary Sewer Manhole	Ground	163 Marshall Ave.	500	Root Intrusion	Pipe blockage due to root intrusion	Sewer line cleaned by jetting and affected area was cleaned and disinfected. Roots have since been removed.
CSO	7/12/2021	Combined Sewer Manhole	Ground	246 Raven Rd.	Unknown	Inadequate Capacity	Known systemic capacity issue	The affected area was cleaned and disinfected. A level sensor was deployed downstream of the area for long-term monitoring.
CSO	8/19/2021	Combined Sewer Manhole	Unnamed Wetland	35 Windward Rd.	Unknown	Inadequate Capacity	Known systemic capacity issue	The affected area was cleaned and disinfected. Insufficient capacity to be addressed through installation of new wet-weather storage as described in Lowell's Phase 3 Integrated Capital Improvement Plan.
CSO	8/19/2021	Combined Sewer Manhole	Ground	246 Raven Rd.	Unknown	Inadequate Capacity	Known systemic capacity issue	The affected area was cleaned and disinfected. Active monitoring via a level sensor downstream of the area was continued.
CSO	9/2/2021	Combined Sewer Manhole	Ground	246 Raven Rd.	Unknown	Inadequate Capacity	Known systemic capacity issue	The affected area was cleaned and disinfected. Active monitoring via a level sensor downstream of the area was continued.
CSO	9/2/2021	Combined Sewer Manhole	Unnamed Wetland	35 Windward Rd.	Unknown	Inadequate Capacity	Known systemic capacity issue	The affected area was cleaned and disinfected. Insufficient capacity to be addressed through installation of new wet-weather storage as described in Lowell's Phase 3 Integrated Capital Improvement Plan.
CSO	9/24/2021	Combined Sewer Manhole	Ground	246 Raven Rd.	Unknown	Inadequate Capacity	Known systemic capacity issue	The affected area was cleaned and disinfected. Active monitoring via a level sensor downstream of the area was continued.
CSO	11/12/2021	Combined Sewer Manhole	Ground	35 Eagle Ct.	Unknown	Inadequate Capacity	Known systemic capacity issue	The affected area was cleaned and disinfected. Insufficient capacity to be addressed through installation of new wet-weather storage as described in Lowell's Phase 3 Integrated Capital Improvement Plan
CSO	11/12/2021	Combined Sewer Manhole	Ground	246 Raven Rd.	Unknown	Root Intrusion	Known systemic capacity issue	Sewer line cleared by jetting and affected area was cleaned and disinfected. Roots have since been removed.

Figure 2-3. Sewer Surcharges & Overflows (2021)



CSO surcharges, defined above to include all surcharge/overflow events from non-permitted structures associated with the combined sewer collection system. SSO surcharges, defined above to include all surcharge/overflow events from structures associated with the separated sanitary sewer collection system, are. Planned corrective actions are noted at all locations where the root cause was determined to be systemic capacity constraints.

2.8 Infiltration/Inflow Control Plan and Annual Report

The following iteration of Lowell's I/I Control Plan was submitted to EPA and MassDEP in March 2022 as part of a requested response to comments, and is now incorporated into the *Annual Clean Water Report* as a fundamental management document. Any changes made to the Infiltration/Inflow (I/I) Control Plan will be reflected herein.

2.8.1 Introduction

This *Infiltration/Inflow Control Plan* documents and summarizes the strategies employed by Lowell Wastewater to identify, characterize, and where possible eliminate infiltration and inflow to its collection system, in accordance with 314 CMR 12.04(2).

Lowell's *Infiltration and Inflow Control Plan* addresses the primary elements described in [Section 2.8.2](#), including:

- (a) An ongoing program to identify and eliminate sources of infiltration and inflow. The program is funded through the collection system operation and maintenance budget as described in [Section 3.3](#).
- (b) An inflow identification and control program that focuses on the disconnection and redirection of public and private sources of inflow during redevelopment projects, and storage and treatment of existing public and private inflow as described in Lowell's Phase III LTCP submitted under cover of the ICIP in December 2019.
- (c) An ongoing program for continual evaluation of the sewer system—modified from the Guidelines in consideration of the unique character of Lowell's combined sewer system and the scope and intensity of capital projects necessary under Lowell's Phase III LTCP—to determine its existing condition, the presence and quantity of infiltration and inflow into the system, and locations and risks of wet weather sanitary sewer overflows or by-passes in the sewer system. The Infiltration/Inflow Analysis specifically assessed the risk of sewer system overflows for an observed storm similar to the five-year, 24-hour storm event.
- (d) The infiltration and inflow control plan also includes a program to address impacts from new sewer connections and extensions to the sewer system, through consistent application of the principles governing the site-planning review program.

Further detail pertaining to the elements of Lowell's Infiltration and Inflow Control Plan can be found in [Section 2.8.3](#).

2.8.2 Regulatory Requirements

This section details the regulatory requirements incumbent upon Massachusetts municipalities related to the management of infiltration and inflow (I/I) in public sewerage infrastructure. [Title 314](#) of the Code of Massachusetts Regulations (CMR) covers the Division of Water Pollution Control. [314 CMR 12.04\(2\)](#) specifically addresses the requirement "to develop and implement an ongoing plan to control I/I to the sewer system," and stipulates that the plan shall include:

- (a) An ongoing program to identify and eliminate sources of infiltration and inflow. The program shall include the necessary funding level and the source(s) of funding to implement the program.
- (b) An inflow identification and control program that focuses on the disconnection and redirection of public and private sources of illegal inflow. Priority shall be given to removal of public and private inflow sources that are upstream from, and potentially contribute to, known areas of sewer system backups and/or overflows.
- (c) A phased evaluation of the sewer system, consistent with the Department's Guidelines for Performing Infiltration/Inflow Analysis and Sewer Systems Evaluation Survey, to determine its existing condition, the presence and quantity of infiltration and inflow into the system, and locations and risks of wet weather sanitary sewer overflows or by-passes in the sewer system. The Infiltration/Inflow Analysis may assess a range of design storms, but shall specifically assess the risk of sewer system overflows for a five-year, 24-hour storm event.
- (d) For those sewer system authorities with NPDES discharge permits for combined sewer overflows, and for all sewer systems tributary to such sewer systems, and for other sewer systems which the Department specifically determines are at risk of wet-weather sanitary sewer overflows (SSOs), the infiltration and inflow plan shall also include a program to address impacts from new sewer connections and extensions to the sewer system. All sewer system authorities shall include provisions in their I/I plan for mitigating impacts from any new connections or extensions where proposed flows exceed 15,000 gallons per day. Such mitigation shall require that four gallons of infiltration and/or inflow be removed for each gallon of new flow to be generated by the new sewer connection or extension, unless otherwise approved by the Department. The sewer system authority or the Department may require a higher removal rate per gallon of new flow in sensitive areas such as where overflows have the potential to impact drinking water supplies or nitrogen sensitive areas.

The requirements of 12.04(2) refer directly to a report issued by the Massachusetts Department of Environmental Protection (MassDEP) in May 2017, entitled [Guidelines for Performing Infiltration/Inflow Analyses and Sewer System Evaluation Surveys](#) (MassDEP, 2017), hereafter referred to as the Guidelines.

The Guidelines state that:

Extraneous water from infiltration/inflow (I/I) sources reduces the useful life, and the capacity of sewer systems and treatment facilities to transport and treat domestic and industrial wastewaters.

Infiltration enters a sewer system through defective sewer pipe joints, breaks, or manhole defects, and occurs when existing sewer lines and manholes undergo material and joint degradation, as well as when sewer lines are poorly designed and constructed.

Inflow normally occurs when rainfall enters the sewer system through direct connections such as roof leaders, yard drains, catch basins, sump pumps, defective

manhole covers and frame seals, or indirect connections with storm sewers. The mitigation of I/I by sewer system rehabilitation and inflow source removal, combined with an on-going operation and maintenance program, is essential to protect the environment and the significant capital investment in sewers and wastewater treatment facilities made by cities, towns and the Commonwealth.

While this Guidance sets forth an approach to implement an I/I removal program, MassDEP will consider alternative approaches on a case-by-case basis when reviewing plans under 314 CMR 12.04(2). Any alternative approaches should have the same goal of identifying and removing excessive I/I and the sewer system authority should document the advantages of an alternative approach.

The Guidelines further describe the typical measures taken to comply with these requirements as follows:

The I/I analyses are typically divided into the following phases or tasks:

- Infiltration and Inflow Analysis
- Sewer System Evaluation Survey
- Sewer System Rehabilitation
- Follow-up Analysis

The following sections present the status of these phases, as implemented at Lowell Wastewater, which has modified and/or deferred some portions of these tasks in recognition of the particular challenges of implementing an I/I program in a combined sewer system. These particular challenges are addressed directly in the Guidelines, as follows:

MassDEP also recognizes that many sewer system authorities in Massachusetts have combined sewer systems, and as such, have been designed to collect and convey stormwater flows in addition to sanitary flows. These systems in nearly every case also have combined sewer overflow structures included in their NPDES discharge permits. Communities with CSO discharges are subject to a separate regulatory framework, including the state and federal CSO Control Policies and Guidance. In these communities, the I/I control plan should be consistent with the Long-Term CSO Control Plan, which may supplant the I/I control plan in its entirety, and have approaches and recommendations which differ from approaches in separate sewer systems.

Lowell Wastewater submitted its first Integrated Capital Plan (ICP) in 2019, which included the results of recent sewer-system flow monitoring and model updates, and a comprehensive review of alternative control strategies considered for control of inflow to the combined sewer system with the objectives of minimizing permitted CSO discharges and eliminating prohibited CSO surcharges.

While Lowell Wastewater continues to invest significant resources in its LTCP to mitigate CSO frequency, duration and volume, the LTCP is restricted in scope to the management of otherwise irreducible infiltration and inflow in the combined sewer system. It is not envisioned as a comprehensive framework for I/I control and reduction because Lowell Wastewater is committed to addressing cost-effective measures for the reduction of infiltration and inflow through other ongoing programs, as well.

The following sections presents all principal components of I/I control strategies in Lowell in more detail than was provided in the ICP submission, but also refers back to the ICP for specific details relevant to the LTCP.

2.8.3 Elements of Infiltration and Inflow Control in Lowell

This section presents the elements of Lowell Wastewater's I/I Control Plan as currently envisioned. Taken as a whole, these elements seek to satisfy the four distinct requirements of 314 CMR 12.04(2), sub-sections (a—d), as discussed above.

The primary elements of Lowell's Infiltration and Inflow Control Plan are:

1. Identification/Investigation
2. Infiltration Removal
3. Public Inflow Removal
4. Private Inflow Control

These four programs comprise the I/I Control Plan for the City of Lowell as follows:

- Lowell implements extensive identification and investigation practices throughout its collection system directed towards I/I source location and characterization. Citizen notification alerts ensure the utility is aware of any issues having an active impact on the community. Sewer system conductance surveying acts as an efficient and effective tool for screening and identifying sources of infiltration and inflow within the collection system. System wide surveying is completed as part of a long-term effort to characterize the conductance of sewage throughout the collection system during periods representing both high and low groundwater and streamflow for the purpose of determining areas of low relative conductance. Further investigation via video inspection, flow metering and other subsequent control actions allow for Lowell to better understand the nature and impact of the identified issues, ensuring that an effective solution is designed and implemented in a timely manner;
- Lowell manages the removal of infiltration from within its collection system through routine lining projects identified through video inspections, as well as the other investigative measures described in this plan. These collection system lining, repair and replacement efforts are an integral part of Lowell Wastewater's collection system Capacity, Maintenance, Operations and Management (CMOM) Program and is structured as an ongoing effort to investigate the entirety of the collection system (combined and separated) and evaluate and prioritize repairs needed to ensure system integrity and reduce infiltration. Once identified, these repair projects are then completed through ongoing contracts or through integration into the City's Integrated Capital Plan (ICP), depending on the scope and cost of repairs or replacements determined to be necessary;
- Lowell removes public inflow from its collection system through the implementation of targeted sewer separation projects that aim to eliminate inflow related issues that are causing direct impact to the community first. Potential small-to-medium scale targeted sewer separation projects are reviewed following a triple-bottom-line approach, which takes community impact,

cost and feasibility into consideration when determining which projects should be pursued first. Rather than simply base sewer separation projects on the grounds of total inflow removal, Lowell believes that it is more equitable to the community to develop separation projects that will alleviate pervasive surcharging and street flooding issues caused by the most impactful inflow.

- Lowell controls private inflow entering into its collection system through the implementation of a stormwater detention requirement on qualifying private properties that are undergoing substantial redevelopment investments. The private inflow control program is an interdepartmental working group of appropriate staff from the Department of Planning and Development, City Engineering and Lowell Wastewater and is convened to review proposed site-development projects to consider how such proposals may be subject to constraints within the City's wastewater and stormwater management programs and related ordinances.

The remainder of [Section 2.8](#) presents each element of the I/I Control Plan in more detail.

2.8.4 Identification of Infiltration and Inflow in Lowell's Collection System

Lowell Wastewater employs a variety of different techniques and technologies useful in identifying and investigating infiltration and inflow entering into its collection systems. These efforts are closely related to, and run in tandem with, Lowell's collection system Capacity, Management, Operation and Maintenance (CMOM) program. The reader is referred to Section 3.4 for more details.

Community Reporting of Street Flooding

Citizens are able to notify Lowell Wastewater of any observed or experienced performance issues with the collection system through a reporting tool hosted on the City's website. Notifications submitted through this tool trigger an automatic email alert to be sent out to appropriate Lowell Wastewater personnel. These alerts serve as a triggering event which prompt the utility to investigate the area of concern. While not every reported issue is caused by excessive infiltration and inflow entering the system, previously unknown sources of I/I can be discovered during these investigations.

Once the appropriate personnel are notified, a record of investigation is initiated using ArcGIS Online's Workforce tool. A point feature is created at the area of concern on a digital map of Lowell, hosted on the Workforce application, by Lowell's Collection System Manager. This point feature acts as a digital record denoting the need for follow-up investigation.

Video Inspections

Lowell Wastewater owns and operates a sewer inspection vehicle that is equipped with and records video inspections. As new video inspections are performed, they are recorded to Lowell's GIS database through integration with GraniteNET technology onboard the video truck.

Inspections are coordinated to follow an active paving program run by the City engineering department. Additional inspections are deployed to other priority sections of the collection system through the submission and receipt of inspection requests on an as-needed basis. Further information can be found in [Section 3.4.4](#).

Sewer System Conductance Surveys

Conductance is a measure of electrical conductivity (or dissolved ions) in water. Typically, sewage has a high specific conductivity in the range of 1,000 micro-Siemens per centimeter ($\mu\text{S}/\text{cm}$). Sections of the collection system with high I/I tend to dilute the sewage and lower the conductance, offering a low-effort screening tool to identify areas of the system in need of further inspection and repair.

Lowell Wastewater established sewer system conductance surveys as a pilot project in 2018. Lowell's sewer system conductance surveying program is specifically designed to identify primary points of entry for I/I by utilizing specific conductance probes to screen the collection system at 77 major junctions and other vulnerable points near wetlands and river crossings. Readings are entered into Lowell's GIS database so that they can be easily reviewed in online management dashboards for follow-up actions, which may include flow metering at specific targeted areas, and/or dispatching the video truck to areas of interest for visual assessment of pipe condition and repair needs. Conductance values are ranked into three tiers: high priority (0 - 399 $\mu\text{S}/\text{cm}$), normal priority (>399 – 799 $\mu\text{S}/\text{cm}$), and low priority (>799 $\mu\text{S}/\text{cm}$).

While any decrease from the expected conductance range can be indicative of I/I related issue, addressing the instances of highest priority first will result in a more immediate reduction in total system I/I: Lowell Wastewater views this approach as a better allocation of limited resources. Since this screening method is particularly useful in identifying infiltration rather than inflow, remedial solutions tend to be easier to implement, as they are typically more focused around system restoration as opposed to system installation. Higher conductivity values may be due high-conductivity wetland waters entering into the collection system, or to discharges to the sewer system warranting investigation for reasons outside the scope of I/I control. These results, while cataloged, are considered to be less of a "smoking gun" than lower conductivity results, and as such, are not prioritized for immediate further investigation.

Figure 2-4. Conductance Survey Pilot Results



Figure 2-4 above illustrates one significant inflow source to the collection system in downtown Lowell where a drainage connection from the Merrimack Canal was found to be contributing inflow into the combined sewer system and Dutton and Market Street. The two red dots indicate, respectively: a manhole in which very low conductance readings were observed (136 $\mu\text{S}/\text{cm}$), and the conductivity of the canal water adjacent to the manhole (123 $\mu\text{S}/\text{cm}$). These values can be contrasted to the yellow markers indicating the expected range of conductance in Lowell's sewage (977-1045 $\mu\text{S}/\text{cm}$). The connection inferred was later confirmed by video inspection and sealed in the fall of 2018 after discovery, eliminating

50 GPM of flow in the process. This pilot project was initially intended to help identify potential hot spots of suspected infiltration in the riverbank interceptors; however, the success of the pilot project in quickly identifying, tracing and resolving a previously unknown inflow source has led to an expanded, ongoing program.

Level Sensor Monitoring

Lowell actively maintains a collection of six level sensors strategically deployed throughout its collection system, at areas with reported or reoccurring conveyance issues. These level sensors measure and collect level and velocity profiles over user-specified time intervals across an established deployment period (see [Section 3.4.1](#) for more details).

2.8.5 Public Infiltration/Inflow Removal

Lowell Wastewater removes public infiltration and inflow from its collection system through its Collection System Lining, Repair and Replacement Program and its Targeted Sewer Separation Program.

Collection System Lining, Repair and Replacement

The deterioration of the sewerage system, of which infiltration is a symptom, is a factor of critical concern to Lowell and is addressed through Lowell's collection system Capacity, Management, Operation and Maintenance (CMOM) program. Lowell Wastewater conducts regular system cleaning and inspections in collaboration with the City Engineer's paving program, which sees an average of 14 miles of sewer pipe cleaned and inspected each year. Point repairs, replacements and lining projects uncovered during the inspection process are carried out through ongoing annual contracts. Larger replacement projects that require significant engineering design and construction costs are reviewed in the context of Lowell's ICP and prioritized for completion accordingly.

Pipe conditions are characterized using a scale from one to five, with five being a serious defect that requires immediate attention. Inspection reports are generated using software on the video truck; reports are reviewed during bi-weekly collection system meetings to identify the pipes that require rehabilitation. The benefits realized through this program include reduction of infiltration to the sewerage system as deteriorating components are continually repaired, replaced, or lined to restore structural integrity.

For more detailed information on this program, the reader is referred to Section 3 of this document.

Targeted Sewer Separation

Lowell Wastewater has invested significant time and capital, among other resources, over the past twenty years towards reducing the total area of the city served by a combined sewer collection system. This effort has contributed in seeing approximately 44% of Lowell's total sewered area be converted from combined to separate sewer servicing; an effort predominately done in the western and southeastern portions of Lowell, costing over \$58 million in the process. Lowell recognizes the need for, and believes in the importance of, sewer separation within the context of I/I control; however, due the limited availability of the resources necessary to complete traditional, large-scale sewer separation projects on a regular basis, Lowell Wastewater has decided to reconsider its approach and implement sewer separation efforts in a more targeted manner that factors triple-bottom-line cost-benefit analytics with respect to local flooding relief into the deciding framework by which separations projects are developed and implemented.

Rather than attempt to remove the most I/I possible through large scale separation, Lowell's targeted sewer separation program addresses the removal of the most impactful I/I from the collection system. Beginning with the residential alerts described in [Section 2.8.4](#), Lowell Wastewater utilizes these notifications as a trigger to warrant further system investigation, on the grounds of establishing candidacy for sewer separation as a solution. By going after I/I that is having a known direct impact on the community, at its source, Lowell is implementing mitigation efforts in a timely and equitable manner.

Once the reported incident is inspected and it is confirmed that the cause of concern was not situational in nature (i.e. catch-basin grates covered in debris resulting in poor drainage, a large pool being improperly drained into the street, etc.), further investigative efforts are taken to better characterize the issue. These efforts include:

- In-house GIS record and system plan analysis of the impacted area;
- The long-term use of flow metering and level monitoring equipment deployed at, and downstream of, the reported area of concern, to characterize frequency and intensity of the flow over time through the affected area;
- The use of conductance surveying at, and directly downstream of, the reported area of concern, to better understand the source of any high flows related to the issue;
- Collection system cleaning and video inspection of the area of concern.

The data collected through these investigatory measures is essential in Lowell Wastewater developing an understanding of any uncovered issues with its collection system. This data is reviewed during bi-weekly collection system meetings, in which Lowell Wastewater program managers and City Engineers determine whether an appropriate solution is within the capability for in-house staff to manage, or if the required solution is too large in scope, and needs to be put out to bid. For work deemed feasible to be completed in-house, Lowell Wastewater seeks input from its engineering consultant with respect to design and creating a triple-bottom-line cost-benefit analysis of the proposed solution. Construction and implementation of the final design is tasked to Lowell Wastewater's system contractor, with regular oversight by appropriate utility personnel. Projects deemed too cumbersome to be completed by in-house staff, or of minimal cost-benefit, are cataloged and compiled with other projects into a package of sewer separation projects to be completed at a later time.

When there are no longer any citizen notifications to investigate, conductance survey results and GIS record analysis are prioritized for establishing candidate areas for targeted sewer separation projects.

As described in [Section 2.8.4](#), Lowell Wastewater employs routine conductance monitoring throughout its collection system that has proven successful in identifying I/I related issues. Conductance survey results are grouped and analyzed for trends to determine if the respective systems are good candidates for sewer separation.

In some areas of the combined sewer system, drains were installed in the streets, but were eventually reconnected to the existing combined system if there was no accessible receiving waterbody nearby. These areas are reviewed to see whether expansions to the existing system can be made to fully separate

it; expansions can include the installation of new pipe to a newly created outfall, construction of an infiltration system, or connection to an existing separated drainage system.

Additionally, it is the case in Lowell that while there may be areas served by both separate drainage and sewer, random catch basins may still be connected to the sanitary sewer. These catch basins are identified as part of an ongoing system mapping effort driven by Lowell's MS4 permit and IDDE program. These catch basins are cataloged as they are found, following which, efforts to establish a connection to area drainage are made. Lowell wastewater views this work as the smallest-scale separation project that can be done. Funding of these efforts is an ideal candidate for offsite stormwater mitigation fees collected through Lowell's private inflow control program.

2.8.6 Private Inflow Control

Lowell has developed a private inflow control program which establishes criteria to require private inflow removal from highly impervious properties within the city that are undergoing substantial reinvestment. Projects that meet the criteria thresholds are required to detain the first inch of rainfall that falls across the impervious area on site. This is done in an effort to mitigate the effects that peak rainfall has on the collection system and minimize this rainfall's contributions to downstream sewer surcharges.

Site Planning Review Program

Lowell Wastewater, in a collaboration with the City Engineer's office and the Department of Planning and Development (DPD), has developed a robust, methodical and equitable approach towards alleviating private inflow entering into its collection system, through the review and approval of site-specific stormwater management practices, triggered by new and redevelopment project investments within the City of Lowell. Lowell's Stormwater Management Team, consisting of Lowell Wastewater's Engineering Manager and Stormwater Program Manager, review all proposed site plans brought before the City's Project Review Boards to ensure that impacts from new construction and redevelopment activities are properly managed to protect the City's collection system infrastructure and meet overall objectives of environmental protection.

All proposed site plans are first considered in the context of whether they are subject to the jurisdiction of the Wetlands Protection Act and by proxy the Massachusetts Stormwater Standards, or if the Lowell Stormwater Standards are the governing standards that must be upheld. Lowell's City Ordinances provide Lowell Wastewater with the authority to reject or approve these plans, and provide standards and specifications for the developers to follow.

For projects that fall under WPA jurisdiction, the Stormwater Management Team provides feedback to Lowell's Conservation Commission related to the extents to which the WPA is applicable, and what they see as an appropriate level of stormwater management for the site in question. Final authority as to whether the project meets WPA criteria resides with the Conservation Commission, and Lowell's Stormwater Management Team strictly serves in an advisory role for these types of projects.

Projects that fall outside of WPA jurisdiction are reviewed to see whether the Lowell Stormwater Standards are applicable and appropriate for the proposed project. The Lowell Stormwater Standards aim to seek a reduction in peak flow runoff from entering the collection system by requiring commercial

property owners to detain and remove the first inch of rainfall that falls onto the impervious ground cover of their site, and residential property owners to detain the first inch of rainfall that falls onto their roof cover. The focus of these standards is to remove the inflow that contributes to initial peak flow volumes that have an effect on combined sewer overflow, and to establish controlled inflow into the collection system thereafter.

To determine if the Lowell Stormwater Standards are applicable to a project, the proposed site plans are first considered in the context of whether they are within a combined or separated sewer service area. In separated service areas, the following conditions apply:

- Both private and public inflow is prohibited from entering into a separated sewer system, and all stormwater runoff from private development to Lowell's municipal drainage system is managed in accordance with Lowell's Stormwater Management Program (SWMP).
- New sewer connections are evaluated to ensure that the expected flows do not contribute to exceedance of the design flow of downstream sewer systems.
- For commercial development that sees an acre or more of disturbed area, the Massachusetts Stormwater Standards are applied.
- For commercial development that sees less than acre of disturbed area, the property owner is required to adhere to an operations and maintenance plan tailored for the site. This O&M plan encompasses routine inspection, evaluation and maintenance of any paved areas and pre-existing stormwater infrastructure found onsite.
- Residential development projects are not subject to any Lowell Stormwater Standards.

For projects that are proposed in combined service areas, the following considerations are made:

- New sewer connections are evaluated to ensure that the expected flows do not contribute to exceedance of the design flow of downstream sewer systems.
- Applications are vetted to see whether the proposed work is being done to a commercial or residential property; residential redevelopment is met with more flexibility with respect to the extent of which the Lowell Stormwater Standards applied.
- The site grading and drainage is evaluated to determine whether onsite stormwater management controls may be feasible. Commercial properties with high percentage of impervious area are prioritized for inflow removal, while residential properties are given greater flexibility, which is consistent with the Massachusetts Stormwater Standards.
- Projects are evaluated to determine if a substantial investment is being made to the property as part of the proposed redevelopment. A substantial investment is viewed as a significant cost investment, or increase in impervious cover, being made over the course of the project. For commercial projects, the substantial investment threshold is set at 20% cost investment (relative to the pre-existing property value) up to \$500,000, and/or 20% impervious ground cover increase (relative to the pre-existing impervious cover). For residential projects, the thresholds are set higher at 100% cost investment and impervious ground cover increase.
- Commercial properties that are undergoing redevelopment, but not substantial investment, are subject to adhere to an operations and maintenance plan tailored for the site. This O&M plan

encompasses routine inspection, evaluation and maintenance of any paved areas and pre-existing stormwater infrastructure found onsite.

- Residential properties that are undergoing redevelopment, but not substantial investment, are not subject to any Lowell Stormwater Standards.

The intent of the site-planning review program is to gradually reduce the acreage of existing impervious area that is directly connected to the combined sewer system, and to restrict the introduction of peak inflow from created impervious areas to the combined sewer system through consistent application of the policies described above. In certain situations where onsite controls are infeasible or insufficient, newly created impervious areas may be directly connected to the combined system to protect Lowell's citizens against risk of injury or loss of property. In these cases, a connection fee will be required and this fee will be applied to the design and implementation of other inflow-removal projects.

By structuring Lowell's stormwater standards to target smaller projects undergoing substantial property investment, this program is able to alleviate excessive inflow that would otherwise be missed were the Massachusetts Stormwater Standards be the only set of stormwater guidance governing development in Lowell. By having Lowell's stormwater standards be more easily applicable to commercial redevelopment projects, Lowell is able to remove a common impactful source of inflow in an equitable manner. Lastly, by targeting projects that occur in mostly combined service areas, the Lowell stormwater standards raise and promote awareness at the community level of the impact that excess inflow has on combined collection systems, combined sewer overflows, and Lowell's waterways, and the importance of proper stormwater management in alleviating an oftentimes overlooked societal and environmental issue.

Compliance with State Regulations – 4:1 I/I Removal Credit

314 CMR 12.04(2)(d), previously cited in [Section 2.8.2](#) of this document, requires specifically that "All sewer system authorities shall include provisions in their I/I plan for mitigating impacts from any new connections or extensions where proposed flows exceed 15,000 gallons per day. Such mitigation shall require that four gallons of infiltration and/or inflow be removed for each gallon of new flow to be generated by the new sewer connection or extension, unless otherwise approved by the Department."

While new connections of this size are relatively rare in Lowell, they have been known to occur in recent years. In any case, a redevelopment project that increased the contribution of stormwater to the combined sewer greater than 15,000 GPD would not be approved. As stated above, new connections are reviewed to ensure that they do not lead to exceedances of downstream conveyance-system capacity. Therefore, when such a connection to Lowell's collection system is made, targeted sewer separation will be implemented to meet this 4:1 removal ratio.

Consequently, Lowell Wastewater considers its private inflow removal program to be a holistic approach to long-term management of I/I into its combined sewer system. Lowell requires the removal of inflow from certain commercial properties, regardless of whether or not new connections are above the stated regulatory threshold. In particular, in the LTCP with respect to storage and treatment of inflow to prevent surcharges and minimize discharges— Lowell believes this to be a sufficient provision for "mitigating impacts from any new connections or extensions." Lowell respectfully requests consideration and

approval of this approach, in lieu of project-specific I/I removal criteria as suggested in 314 CMR 12. Lowell would appreciate the opportunity to meet with the Agencies and discuss ongoing/future I/I removal strategies, including an approach for accounting of I/I removal to obtain “credit” for compliance with the statute.

2.8.7 I/I Summary for Reporting Year 2021

The average daily flow through Lowell’s Duck Island Wastewater Treatment Facility was 30.3 MGD in 2021. Since the Duck Island WWTF average daily flow exceeded 80 percent of the facility’s 32 MGD design flow (25.6 MGD), this report includes the maximum daily, weekly, and monthly infiltration/inflow values for the reporting year.

At the time of this report, Lowell Wastewater calculates infiltration/inflow as the recorded difference between average daily plant flows on wet-weather and dry-weather days. This methodology relies on the presumption that the increased daily flow that the plant experiences on wet-weather days is caused by the active infiltration and inflow caused by the wet-weather event. As such, Lowell Wastewater is unable to distinguish what percentage of the I/I is strictly infiltration versus the remaining inflow.

A Maximum Daily I/I volume of 42.02 MG occurred on 10/31/2021. A Maximum Weekly I/I volume of 77.50 MG occurred during week 18 of the reporting year (4/25/2021 – 5/1/2021). A Maximum Monthly I/I volume of 171.71 MG occurred during October 2021.

This page intentionally left blank

Table 2-9. 2021 Monthly Infiltration and Inflow Rates

Annual Infiltration-Inflow Rates						
Month	Days With Precipitation (Wet Days)	Days Without Precipitation (Dry Days)	Monthly Plant Rainfall	LRWWU Avg. Daily Flow		Avg. Rain- Related I/I
				Wet Days Only	Dry Days Only	Wet Days Only
	Days	Days	inches	MGD		
Jan '21	6	25	2.4	34.27	27.25	7.02
Feb '21	11	17	2.2	26.29	24.39	1.90
Mar '21	7	24	1.9	30.50	26.70	3.80
Apr '21	10	20	6.7	39.22	27.25	11.97
May '21	15	16	5.4	40.31	29.85	10.46
Jun '21	10	20	1.9	28.80	24.98	3.82
Jul '21	22	9	9.3	39.64	35.19	4.45
Aug '21	9	22	4.4	35.54	26.28	9.26
Sep '21	12	18	5.8	37.13	30.05	7.08
Oct '21	10	21	6.3	42.68	25.78	16.90
Nov '21	8	22	2.5	33.68	29.94	3.74
Dec '21	14	17	3.5	29.94	25.65	4.29
Total/Average	134	246	4.4	34.83	27.78	7.06

3. CMOM Program Plan and Annual Report

Lowell Wastewater has developed and implemented a detailed Capacity, Management, Operations and Maintenance (CMOM) program for its collection system since completing a self-review following EPA's CMOM guidance (US EPA, 2005) in 2011. The CMOM program guidance structure is followed in this report for the convenience of regulatory agency representatives who may be tasked with reviewing Lowell's program.

Lowell's recently re-issued NPDES permit requested submittal of a 'Collection System Operations and Maintenance Plan' that describes collection-system management goals, staffing, information management and legal authorities, and overall condition description and discussion of recent studies and activities. As these requirements have been regularly fulfilled through this section of the annual report, the requested submittal is provided herein. In the next 6 months, Lowell will be developing a full 'Collection System O&M Plan' that focuses on the preventative and remedial maintenance necessary to ensure optimal system performance and I/I control: this plan is on schedule to be completed by August 2022.

3.1 Collection System Management

The purpose of Lowell's collection system is to protect public health and the environment by conveying sewage wastes to the Duck Island Wastewater Facility for treatment, and to prevent unnecessary property damage from flooding or sewer surcharging. The primary objectives of the CMOM program are to ensure that all work necessary to provide maximum conveyance of wastewater to the treatment plant is performed in a timely manner and to industry standards.

To this end, Lowell's collection system is managed by the Collection System Supervisor, who works in coordination with other Maintenance, Operations and Engineering staff to plan, perform and document the physical and operational states of the assets that make up the collection system: catch basins and manholes; sewer laterals, mains, trunk lines and interceptors; pump stations; communications networks, sensors and associated automated equipment.

The Collection System Supervisor also responds actively to customer requests regarding sewage back-ups and surcharges, and participates in bi-weekly collection-system meetings to identify, discuss and address performance issues related to the CMOM program.

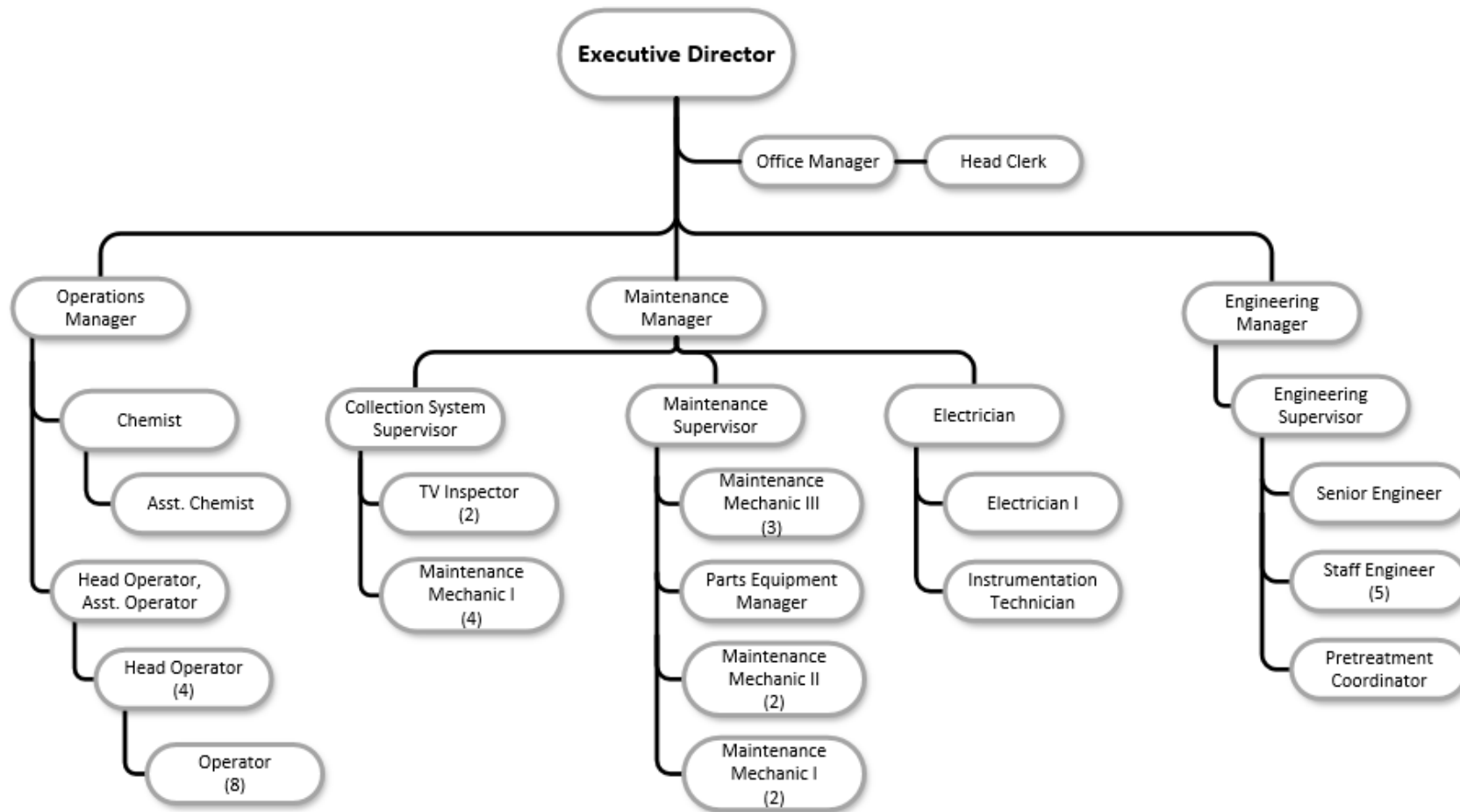
3.1.1 Organizational Structure

An organizational chart depicting authorities and positions of all staff at Lowell Wastewater is provided in [Figure 3-1 Lowell Wastewater Organizational Structure](#), below. Job descriptions are maintained by the Office Manager and include the nature of the work performed, minimum requirements for the position, special qualifications and certifications or licenses that are required. For positions that require licenses with annual training credit hours (TCHs), Lowell provides reimbursement for training and flexibility for staff to attend necessary training during work hours if properly planned. Advancement through the ranks is encouraged through multiple practices, including: educational reimbursement for advanced degrees; annual stipends for certifications achieved and maintained; and preferential notice of and consideration

for open positions. Such practices allow Lowell to retain talented workers with critical system knowledge and experience, and to place high-performing individuals in charge of critical programs like CMOM.

In addition to the work conducted by internal staff, many projects in CMOM are contracted out to third-party vendors. Projects implemented by contractors are identified as discussed in the remainder of this section. Lowell Wastewater also utilizes year round part- and full-time interns to help meet the demands of our CMOM program.

Figure 3-1 Lowell Wastewater Organizational Structure



3.1.2 Lowell Wastewater Internal Communication

Internal communication at Lowell Wastewater is practiced through both formal and informal arrangements. Divisional staff members meet informally but regularly within their division to discuss work plans, objectives and resource requirements as needed.

More formally, Lowell's ISO 14001 Environmental Management System requires quarterly meetings of an Implementation Team (I-Team) that is composed of staff members from each division to ensure that environmental awareness objectives are discussed between departments. As necessary, each I-Team member communicates with staff in their division regarding EMS updates (e.g., recycling program effectiveness, updates to environmental impacts associated with staff positions, updates to standard operating procedures related to work duties, et cetera).

Divisional management meets regularly to discuss all primary program areas, and personnel involved in these program areas are required to attend these meetings. Such meetings are held on a structured, ongoing basis and include:

- Bi-weekly collection system meetings (sewer system inspection and maintenance actions, problem areas, capacity analysis, contractor activities, safety, review and response to any violations, prior action items)
- Bi-weekly private I/I control meetings (plan review of proposed redevelopment projects to mitigate potential I/I related impacts from occurring within the collection system)
- Bi-weekly construction meetings (during new construction; construction progress, budget and schedule)
- Bi-weekly high-flow management (HFM) meetings (high-flow treatment performance review and optimization)
- Weekly process control meetings (treatment facility key performance indicators, process modifications and improvements, upgrades, odor complaints, sludge handling, review and response to any violations, prior action items)
- Monthly safety meetings (concerns raised by personnel or citizens, response to concerns, training schedule, seasonal needs, review and response to any safety incidents, prior action items)
- Monthly integrated planning meetings (planning agenda, schedule, consultant progress, data needs, regulatory and stakeholder coordination)
- Monthly standard and specifications development meetings (review of Lowell

Having such frequent and recurring meetings between management, personnel, contractors and consultants by program area ensures that all internal and contracted personnel remain informed of overall program activities and objectives. Continual review of each program on a regular basis provides ample opportunity for input from all levels of the organization and proactive response to problems both before and after they may occur. Meeting minutes are maintained by each meeting facilitator to document all issues identified and corresponding responses.

3.1.3 Customer Service

Lowell maintains several lines of communication with its customers to provide opportunities for feedback and notification of problems or concerns:

- Head operators receive phone calls and voice messages (reviewed promptly each day) and maintain a log of complaints and concerns expressed by citizens. If a complaint is received about the collection system, the Collection System Supervisor is notified to investigate; if a complaint is received about odor, the operators investigate potential odor sources and maintain a log of such complaints and actions.
- Front office staff receive calls and forward any concerns or questions to the appropriate staff.
- The City's website, hosted by CivicPlus, provides an online entry point for citizens to file requests or complaints related to each City department. Messages related to the water and wastewater utility are sent to the Executive Director, and are forwarded to appropriate personnel for response. For example, individuals may request to be added to the Lowell Waster's CSO notification list through a web form accessible on the City's website (see [Section 2.2.4](#)).
- Field personnel often receive feedback from concerned citizens while conducting work and convey such concerns to the Collection System Supervisor or other appropriate personnel.
- Engineering staff frequently meet with watershed advocates to increase internal awareness of water-quality issues and concerns and, where possible, provide information related to those concerns; engineering staff also meet as requested with professors from various local institutions to support educational requests.
- The Executive Director regularly attends City Council and other public meetings when wastewater, drinking water or stormwater topics are scheduled for discussion to listen to concerns and provide an appropriate and timely response.

3.1.4 Management Information Systems

Lowell's Management Information Systems (MIS) Department supports many of Lowell Wastewater's needs for standard technology services (general purpose hardware, software, internet service protocol, email, procurement, payroll and financial records, CMMS work-order system, et cetera). The City's Geographical Information Systems (GIS) Department provides specialized technical assistance for support of GIS needs at Lowell Wastewater (ArcMap 10.5.1 and extensions, map development, ArcGIS online tools and services).

MIS services are further summarized as follows:

- Procurement, payroll and financials – the City uses MUNIS, an integrated database management system specifically tailored to the needs of municipal governments. MUNIS supports financial management including a multi-fund accounting system, personnel and payroll, procurement processes, tax billing and collection, city permitting and utility billing.
- CMMS work-order system – the City uses MP2 to schedule preventive maintenance tasks, maintain labor records and generate work orders.

Uses of GIS that are supported by the GIS Department include:

- Sewer system
- Municipal drainage system mapping
- Flood protection mapping
- ArcGIS online tools supporting field data collection

For support of information systems particular to the wastewater utility, specific technology vendors have been reviewed and selected. These are described below:

- Supervisory Control and Data Acquisition (SCADA) – General Electric’s iFix system is used to monitor collection and treatment system information at critical points and relay data back to the Operations Center at Duck Island.
- Hach Water Information Management Systems (WIMS) – An OpsSQL database imports specified treatment process and collection system data at frequencies necessary for analysis, presentation and discussion, long-term planning and regulatory reporting requirements.

Summary of MIS/GIS Updates and Related Issues in 2021

Lowell Wastewater reviewed several CMMS platforms capable of GIS integration in 2017. In prior reports it had been stated that an improved solution would be selected and implemented during the 2018-2020 period to support an integrated asset-management system linking work orders, GIS, asset criticality ranking, and vulnerability factors, among other desired features. Further review of potential programs identified a pre-requisite need to complete a revision of existing piping and instrumentation drawings and to secure adequate funding for this advanced management system. In 2021, Lowell Wastewater continued to work toward these goals to improve its CMMS, but the expected acquisition date remains dependent on work currently in progress.

Lowell continued to utilize ArcGIS Collector, Workforce and Survey123 for a number of different data management uses by the Engineering Division in 2021. Continued development and distribution of these field-collection applications to select members of other divisions is ongoing, and iterative feedback from these users is leading to broader adaptation and acceptance of these applications to capture relevant details of work performed in the collection system.

Bi-weekly GIS and Data Management meeting was created to support ongoing improvement of field mapping and data-quality review procedures related to the Utility’s collection systems. This working group, led by the Engineering division, is also focused on improving integration of daily work-flow documentation with GIS and making greater use of ArcGIS Online and Field Data Management applications.

The end goal of this working group is to develop rigorous and well-documented field-data-management procedures to ensure that all relevant information about work done in the collection system is captured in (or is eventually transferred to) the GIS system. However, the final procedures to be adopted will be

contingent upon modification of the current work order system or selection of a new asset management system.

Additional requirements for this data-management program were identified in conversations with Esri water-sector representatives, wherein it was made clear that the common ArcMap platform will expire in four years and be supplanted by ArcGIS Pro and the related Utility Network data schema. The GIS & Data Management team determined that it was in the utility's best interest to seek expert help in developing a finalized Trace Network after making upgrades to Esri's ArcGIS Enterprise. In third-quarter 2021, Lowell enlisted the help of Hazen and Sawyer to facilitate these upgrades, with an expected completion date scheduled for mid-2022.

3.1.5 Sewer Surcharge Notification Program

Lowell Wastewater adheres to all State and Federal regulations requiring notification and reporting of sanitary sewer or combined sewer surcharges. As opposed to combined sewer overflows (CSOs), surcharges of combined sewers result when sewage overflows its conveyance prior to a regulated CSO diversion structure. Lowell very infrequently experiences sanitary sewer surcharges, and has begun commenting specifically on MassDEP reporting forms as to whether a surcharge is in a combined or separate portion of the collection system.

Combined sewer surcharges also occur infrequently, and when they do they are predominantly constrained to known problem areas which is discussed more below. In the event that an SSO or combined sewer surcharge does occur, Lowell Wastewater coordinates closely with the Lowell Police and Fire Departments, which then calls the Collection System Supervisor to notify of the surcharge. Citizens may also report any such issue by filing a complaint on the CivicReady system or by calling the Operations Center at Duck Island. Operators will then notify the Collection System Supervisor. The Supervisor and appropriate personnel from Lowell's maintenance division are dispatched to investigate and remedy the problem (e.g., remove any blockage by flushing the affected sewer line).

Following regulatory requirements, notification to MassDEP and EPA will be made upon becoming aware of the overflow (within 24 hours) and written reports will be submitted within 5 days. Written reports include estimates of the amount of sewage, if any, entering a waterway or drainage system. Subsequent investigation of the affected area may be undertaken, if deemed necessary by the Supervisor, using a robotic camera vehicle to identify the cause of the SSO and confirm whether the problem has been resolved (e.g., grease, rags, etc.) or needs further attention (e.g., root removal or line repair). Elements of the sewer system needing further repair will be prioritized in Lowell's CMMS work-order system.

As of December 21, 2020, Lowell Wastewater is expected to 'provide notification to the public within 24 hours of becoming aware of any unauthorized discharge on a publicly available website'. Given the nature of unauthorized discharges, and the restrictions set in place by the City's Municipal Information Systems (MIS) department on who may have authorization to edit the City's website, it is not possible for Lowell Wastewater to publish unauthorized discharge notifications to the City's website under the criteria set forth in the 2019 permit (Part I.B.2). Instead, Lowell Wastewater is looking to utilize social media to comply with the timeliness of this requirement, by creating an official Lowell Wastewater Facebook page that on-

duty head operators can access and use to post public notification for all unauthorized discharges within the 24 hour timeframe. Operations and Engineering Management are actively working with City MIS on creating a utility social media account that is compliant with City MIS policy.

Sewer Bypass Pumping Authorization Procedure

As was mentioned in prior reporting, a construction-related bypass operation at the Rosemont Pump Station over the summer of 2019 resulted in an unauthorized discharge of sewage to a local waterway (a wetland tributary to the Merrimack River). Immediate corrective actions were taken as soon as the situation was discovered; the incident was reported to MassDEP as a sanitary sewer overflow, the bypass was re-directed into the local sewer system, and the affected area was cleaned of debris. A post-incident assessment found that a combination of improper system knowledge by the proponent, and a lack of regular project inspection by the utility, were the two leading factors in causing the surcharge.

The incident resulted in MassDEP filing an administrative consent order with penalty (ACOP), which included requirements for Lowell to institute a formalized bypass-authorization and -review procedure, as well as identification of specific GIS and records management improvements to ensure that such an incident will be unlikely to occur again. Lowell Wastewater submitted their Sewer Bypass Pumping Authorization Procedure proposal to MassDEP for approval in March 2020. The Authorization Procedure consists of two main components: the Authorization Request and the Authorization Review.

The Authorization Request was developed with the intention of ensuring that any proponent of a sewer bypass pumping project, be it an external contractor or in-house representative, will have a complete understanding of the affected sewer system before an ensuing bypass commences. This is done by having the proponent to provide information specific to the project, as requested in the Authorization Request's four sections [I] – [IV]. The Authorization Request is contained to a single sheet double-sided form, however, digital versions of each submittal section exist online as Survey123 forms.

- Section [I] asks for general information related to the bypass, including, but not limited to, the proponent's contact information, the bypass-run, nearest address and anticipated bypass timeline from start date to end date.
- Section [II] asks for operational information related to the bypass. This section is where the proponent proves that they know the extents of the work, by providing a general description, Lowell-specific GIS IDs for the affected infrastructure, pump model information, bypass flow and volume calculations. The proponent is also required to submit copies of any work plans used in the planning process, and a description of their emergency response protocol and contingency plan.
- Section [III] deals with ensuring that all necessary permits related to the bypass have been obtained.
- Section [IV] acts as a confirmation that the proponent is aware and in understanding of all obligations outlined within the Authorization Request.

Once Lowell Wastewater is in possession of a completed Authorization Request, appropriate staff will review the bypass plan following the structure presented in the supplementary Authorization Review

form. Consisting of five sections [V] – [IX], the Authorization Review was developed to ensure that Lowell Wastewater staff would be competently knowledgeable of any proposed and/or ongoing sewer bypasses set in the City's collection system.

- Section [V] tasks Lowell Wastewater staff with conducting both a GIS based pre-inspection and site field inspection of the proposed bypass location. This process acts to verify that the bypass procedure was designed with an accurate overview of the collection system, ensuring that the bypass can proceed without risk of creating an unauthorized discharge.
- Section [VI] requires the acting Lowell Wastewater Engineering Manager or Supervisor to review all submitted materials thus far.
- Per the revised Sewer Bypass Pumping Authorization Procedure, a representative from Lowell Wastewater shall be present during the start of the sewer bypass. Section [VII] provides confirmation that the bypass was conducted in accordance with Lowell Wastewater's standards.
- Section [VII] serves as a record of any extended bypass pumping project. Any bypass lasting longer than seven days is considered to be extended, and requires that a Lowell Wastewater representative check on it on a weekly basis. An inspection table is included in this section for record keeping.
- Section [IX] acts as a confirmation between Lowell Wastewater and the project proponent that the bypass pumping project was completed in accordance with Lowell's Sewer Bypass Pumping Authorization Procedure. This section requests the signatures of each party, confirming that the sewer bypass has been deemed complete.

Both components of the Authorization Request can be completed through a physical form, or as a digital copy using Survey123. The online version has the potential for the proponent to submit more detailed responses, and it allows for the easy attachment of requested digital documents. Answers to the online form populate a Lowell Wastewater GIS feature class that is used to keep track of the ongoing and historical status of any sewer bypass. The digital version of the Authorization Request is accessible to any project proponent upon request. If Lowell Wastewater receives only a completed physical copy, an electronic digital copy is completed by a Lowell Wastewater representative. The completed electronic Authorization Request serves as the authoritative record; the paper copy gets scanned and added as a PDF attachment to the authoritative copy.

3.1.6 Legal Authority

Lowell Wastewater derives its legal authority from Chapter 272 of the City ordinances. These ordinances provide the Utility, through the City, with the authority to:

- regulate the volume of flow entering the collection system, including residential and commercial customers, satellite communities and industrial users
- ensure that new and rehabilitated sewers and connections have been properly designed, constructed, and tested before being put into service
- establish general and specific prohibitions regarding the use of sewers and drains, including grease control requirements

- establish prohibitions on stormwater inflow, infiltration from laterals, and new construction standards
- maintain strict control over the connection of private sewer laterals to sewer mains
- require inspection and approval of new connections

The water and sewer ordinance was revised in June of 2018 to update the annual sewer use charge and metered service water rates, which became effective after July 1, 2018. In July 2018, a stormwater management ordinance was passed to provide Lowell Wastewater, through the City, the authority to regulate, inspect and require proper management of site stormwater systems throughout the City. Also, in July 2018, the industrial waste ordinance was amended to update the maximum allowable industrial loads (MAIL) permissible to the City's collection system following EPA approval of the revised MAIL.

3.2 Collection System Operation

As discussed in [Section 2.2](#), the primary operational procedure governing Lowell's collection system during wet weather is the High-Flow Management plan. General procedures for the operation and maintenance of specific equipment, stations and substations are maintained in the Maintenance and Engineering libraries, as well as on Lowell Wastewater's intranet.

3.2.1 Hydrogen Sulfide Control

The majority of Lowell's collection system is a combined sewer system, and consequently experiences frequent high-velocity flushing due to inflow. Hydrogen sulfide (H₂S) corrosion has not been found to be a significant cause of deterioration in the collection system during continual video inspection surveys but does remain a concern for worker safety and equipment in remote stations that have wet wells which may be a source of H₂S during dry periods.

Ventilation systems have been installed in these stations in order to protect workers entering the building; structures inspection crews visit each structure daily or weekly (depending on the structure), and so these stations are frequently vented.

3.2.2 Safety

Lowell's Safety Committee meets monthly to discuss and address safety incidents, coordinate and update the annual training schedule, and generally identify any opportunities for improvement to the safety program. Lowell Wastewater's Safety Procedures Manual is a comprehensive document that covers all safety procedures specific to hazards encountered during routine work duties (the Emergency Preparedness Manual, discussed below, covers hazards encountered during emergency and/or extraordinary situations).

Other activities managed by the Safety Committee include procurement of safety equipment, inspection of safety equipment, updates to safety documentation and dissemination of new or revised procedures.

3.2.3 GIS Management

Lowell Wastewater maintains an extensive mapping program that is under continual revision as updates to the collection system are performed. This section details the manner and means by which the GIS resources of the City are leveraged to continually improve the procedures employed at Lowell Wastewater to manage its infrastructure.

GIS Overview

Geographic Information Systems (GIS) technologies are used heavily throughout Lowell Wastewater's programs, as mentioned where relevant in previous sections of this report. GIS is a computer-based system for capture, storage, retrieval, analysis and display of spatially defined or associated data. GIS is one of the basic building blocks of the City's technology services. The goal is to deploy GIS throughout the organization, improving the way services are delivered to residents and businesses. To this end, the GIS department, under MIS, supports databases, develops applications, and provides technical assistance to a growing base of users. The Lowell GIS system was updated in April 2019; the current version is Esri software version 10.5.1, with future plans upgrade to version 10.8.1 in 2022.

The City of Lowell GIS is based on 2013 aerial photogrammetric mapping at a 1"=100' scale. These maps meet or exceed National Map Accuracy Standards (NMAS). The standards ensure that other data such as municipal parcel maps, compiled using similar specifications, can be overlaid without major discrepancies, and that ground coordinates can be derived from the map to a stated accuracy. Lowell GIS data uses the North American Datum of 1983 (NAD83) Massachusetts State Plane Feet. Lowell GIS parcel and boundary lines are compliant to the MassGIS Level 2 Standard.

Lowell GIS layers relevant to wastewater, drinking water and stormwater infrastructure include: building locations, address information, parcel properties, street centerline network, railroads, waterway/wetlands areas, flood plains, paved roadways, schools, neighborhood boundaries, census data, police and fire stations and sectors, zoning, drainage, sewerage and drinking water infrastructure.

Lowell Wastewater has implemented extensive GIS utilization, and we continue to expand our toolbox to maximize efficiency of managing the large amount of data our day-to-day work generates over the course of any given year.

Utility Mapping Procedures

Current GIS mapping procedures include:

- **Sewer System O&M** – Lowell's collection-system staff utilize GIS extensively for operation and maintenance (O&M) of the sewerage and drainage systems. The Collection System Supervisor has Lowell's GIS maps available on an iPad. This enables the supervisor to quickly orient to the local sewers and identify all relevant information about the system. Having this information available in the field allows for expeditious resolution of sewer backups and other O&M issues. Several other Lowell Wastewater personnel also have access to the sewer system maps and information via iPads. These GIS tools facilitate the execution of utility mark-outs, system characterization (feature location and metadata updates), and troubleshooting tasks, making all system O&M tasks

more efficient. When discrepancies are identified in the field, a GIS mark-up tool enables a correction that is sent via email to the Utility GIS coordinator.

- **Sewer Inspection** – Lowell Wastewater owns and operates a sewer inspection vehicle that records video inspections that are integrated into Lowell’s GIS. In 2015, Lowell Wastewater purchased a new video truck to replace its aging vehicle. Through this sewer-inspection program, Lowell Wastewater has identified numerous defects that have led to several miles of sewer rehabilitation and more than \$15 million in sewer improvements over the past decade.
 - As new video inspections are performed, the inspections are recorded in the GIS database through integration with GraniteNET technology onboard the video truck.
 - Changes to existing asset locations and metadata observed in these investigations are submitted through a *map-change request* to the Utility GIS coordinator, and these requests are then completed by the coordinator or are assigned to other appropriate staff for completion.
- **Sewer Outfall Abandonment Confirmation** – Lowell Wastewater’s Engineering Division is open-endedly reviewing old sewer outfall locations that were either abandoned or converted to municipal drainage outfalls during the construction of Lowell’s interceptor system and several sewer-separation projects that have occurred. This effort will ensure that all upstream features are properly designated as components of the sewer or drain systems and prevent misidentification during any future work.
 - Old interceptor plans are reviewed to identify all outfalls annotated as abandoned, and map annotations in ArcGIS online are made to support field investigation and confirmation of abandonment.
 - A field engineer performs site inspections to confirm the abandonment and/or destruction of outfalls, or to confirm the conversion of old sewer outfalls to separate storm drainage.
 - Field notes are then annotated to the old plans as a corrected version, and are updated in the GIS database.
- **Drainage System Characterization** – Lowell Wastewater uses GIS tools to identify and characterize all drainage outfalls into local waterways within the extents of the City of Lowell. This program is mandated by EPA stormwater regulations and is under development to be implemented through Lowell’s MS4 Stormwater Permit. Through this program, the locations of all drainage outfalls will be captured and integrated into Lowell’s GIS. Having these assets integrated into GIS will allow Lowell Wastewater to better operate and maintain them. All drainage pipes are also integrated into GIS, including more than five miles of new drains that have been installed in Lowell Wastewater’s sewer-separation program. As part of Lowell’s MS4 management program, all drainage structures will be investigated and confirmed through GIS in the coming years through an ongoing drainage-system characterization program. The program is

intended to be facilitate an ongoing effort to maintain and improve the accuracy of system records.

- **Project Design and Planning** – As part of Lowell Wastewater’s Long-Term Control Plan (LTCP) program to control combined sewer overflows (CSOs), more than \$50 million has been invested to upgrade Lowell Wastewater’s drainage system and separate inflow/infiltration sources from the combined sewer system. Lowell’s GIS has been utilized extensively to plan, design and document six sewer-separation projects that have resulted in the installation of more than 20 miles of new drains, sewers, and water mains in the past ten years.
 - A comprehensive review of all projects will be conducted to ensure that all abandonments and/or conversion of sewer to drain (or vice versa) have been accurately recorded in the GIS.
 - New infrastructure projects completed in-house or through Lowell’s repair contracts (pipe replacement, new catch basins, et cetera) will be submitted by the Collection System Manager as a map-change request to the Utility GIS Coordinator, who will then update the GIS accordingly.
 - New infrastructure projects completed under large contracts will be asked to submit a GIS project file following Lowell’s sewer and drain geodatabase schemas, as part of the final records submittal, and that will be imported into Lowell’s GIS after a data-quality review by Lowell’s Utility GIS Coordinator.
- **Property Development** – Lowell Wastewater assists property developers when they need information about local utilities. Lowell’s GIS has information on water, sewer, drain, and gas utilities, allowing developers to effectively plan their projects.
 - As new properties are developed within the City, and new connections are made to the water infrastructure (potable, sewer and drain), map-change requests are to be submitted with approval of the new connections so that they are incorporated into the GIS.
- **Resident Support** – When residents inquire about local utilities, Lowell Wastewater is able to provide relevant information immediately. Of particular value to home-owners are records of their sewer services. Although these records are not available through the Internet, they are provided upon request.
- **Spill Containment**– Using GIS, Lowell Wastewater is able to provide quick access to information in determining what is affected downstream of the spill and where to set up spill containment.

GIS Online Services

Originally developed as a means to provide access to Lowell GIS data through a website application and as a component for E-government services, Lowell’s GIS online services incorporate an internal Intranet alongside an external Internet presence.

Using GIS web services, a user can search by criteria such as parcel address or street name and the Lowell GIS site will return an interactive map of the location requested. This allows users to view GIS data, query databases linked to GIS, view related documents and print maps. A mark-up tool has been developed to aid in the correction of the GIS. This continuous editing of the GIS makes it as accurate as possible, using lines, points, polygons, and text on top of the base map of the GIS. These corrections are then sent to the GIS editors and the base maps are revised.

Wastewater Utility Internal GIS

This GIS Site displays the general GIS layers available as well as Wastewater Utility-specific layers. Examples of Wastewater GIS data layers are the city sanitary sewer and drain networks including sewer and drain pipes and wastewater infrastructures as well as other relevant GIS layers.

Lowell also has developed an ArcGIS server website for retrieval and display of sewer service records. This GIS Site designed for the general public through the city website (www.lowellma.gov). This site displays the general GIS data layers include base mapping (roadways, buildings, property and address locations, elevation model, neighborhood, and zoning boundaries, and assessor tax parcels and property data linked to the parcels).

Summary of GIS Improvements and Planning in 2021

Lowell continued to utilize ArcGIS Collector, Field Maps, and Survey123 to support active field work and related activities during 2021.

Wastewater Engineering staff developed and implemented an ArcGIS Workforce application to support CMOM activities. This application was designed to be distribution tool for the Collection Systems Supervisor, by serving as a digital hub for maintenance assignments to be managed, tracked and completed by appropriate personnel. This acts as an effective organizational tool, and ensures that all assigned work is completed in an efficient manner. Furthermore, by utilizing this tool to manage CMOM activities, digital records are created of the work done to the collection system. Having a complete set of digital records is essential to accurately report on Lowell's yearly CMOM activities. Plans exist to better optimize and improve the functionality of the application, including expansion of this tool to incorporate condition assessment, preventive maintenance, and life-cycle costs.

Wastewater Maintenance personnel responsible for operating the utility's vacuum trucks were equipped with iPads fitted with Lowell's ArcGIS application package. Managed by the Collection System Supervisor through the CMOM Workforce application, these personnel completed assignments related to collection system maintenance and reparation activities.

Wastewater Engineering staff developed a Survey123 tool to collect information related to maintenance work done on the collection system by municipal contractors to ensure that this work is in compliance with Lowell's standards.

Limitations of the current GIS architecture have been identified, and Lowell Wastewater has entered into the development stages with the City's MIS department, a team of GIS specialists from Hazen Engineering and Esri to upgrade to Esri's new ArcGIS Enterprise with Portal and Trace Network architecture within

2022. These upgrades are expected to significantly improve the efficiency by which Utility personnel are able to collect field data and improve the City's official GIS record-base.

3.2.4 Lowell Property Development Review

Lowell Wastewater actively participates with the City Engineer's office and the Department of Planning and Development (DPD) in the review and approval of new and redevelopment projects within the City of Lowell. Lowell Wastewater's Engineering Manager and Stormwater Program Manager review site plans to ensure that impacts from new construction impacts are properly managed to protect the City's infrastructure and meet overall environmental protection objectives. The City Ordinances provide Lowell Wastewater with the authority to reject or approve these plans and provide standards and specifications for developers to follow.

Summary of New and Redevelopment Actions and Planning in 2021

Lowell Wastewater, with the City Engineers and DPD, reviewed 79 property improvement projects through the established procedures. The Engineering Manager reviewed all new connections to the sewer and drainage system prior to approval.

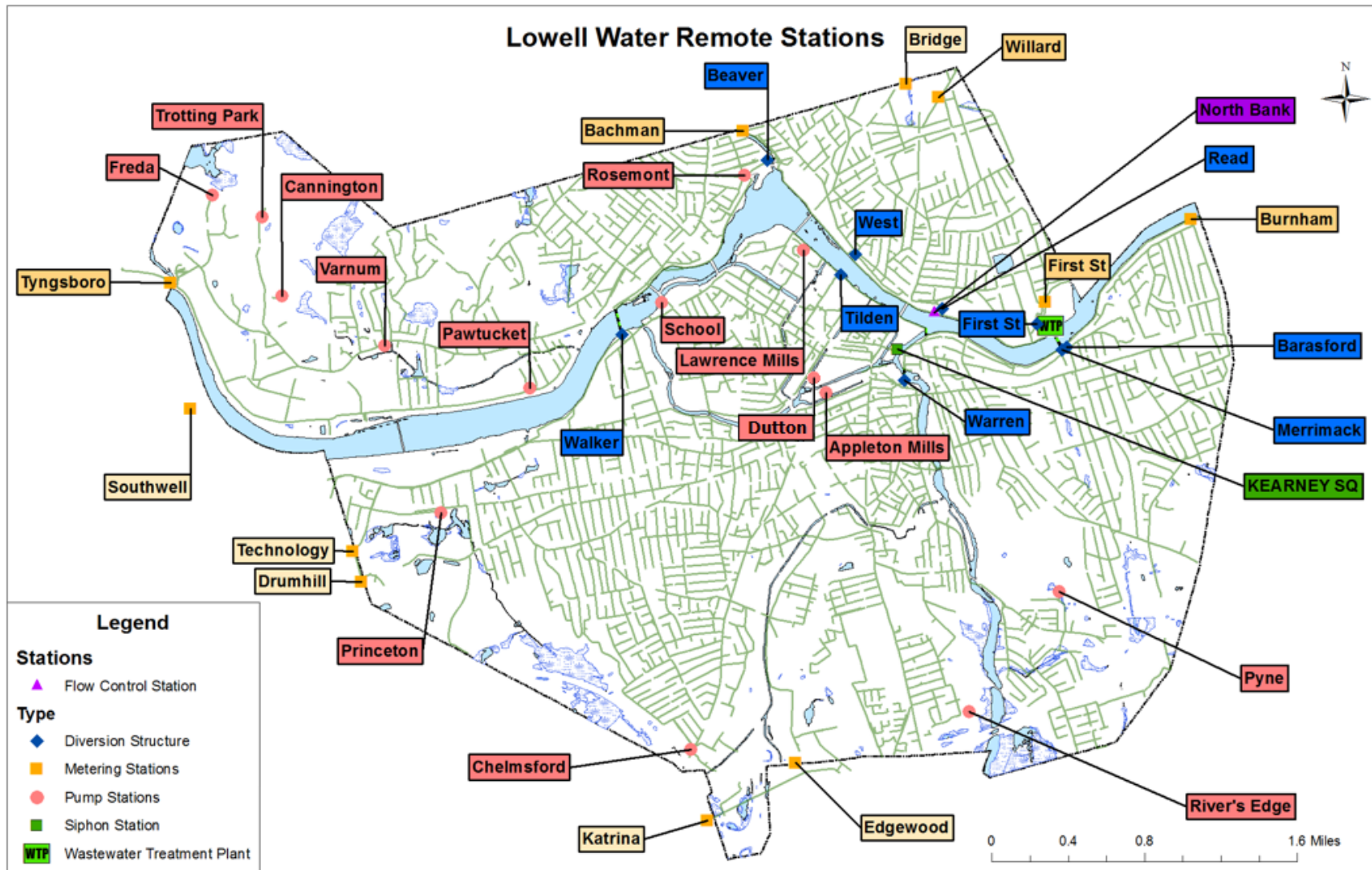
3.2.5 Remote Stations

Lowell Wastewater's collection system includes 35 remote, or satellite, stations which are critical operating components of the collection system. These include CSO diversion stations (DS), pump stations (PS), metering stations (MS), and radio repeater stations (RS). All stations have their own respective operations and maintenance procedures and manual. Remote stations are visited daily by the maintenance structures crew, with the exception of the CSO diversion stations, which are visited on a weekly basis.

Summary of Updates to Remote Stations and Related Actions in 2021

Lowell's capital improvement plan, which included renovation and communications improvements, improvements to conveyance and storage, mechanical systems, electrical and lighting systems, SCADA and instrumentation, HVAC and plumbing, structural repairs and architectural improvements at several of the remote stations achieved final completion in 2021. Lowell also brought a new pump station on Dutton Street online during 2021.

Figure 3-2 Remote Stations Map



3.3 Equipment and Collection System Maintenance

Lowell manages equipment inventories and maintenance needs for the collection system through the MP2 CMMS software package. The MP2 database is populated with an equipment inventory that includes all items requiring maintenance at the Duck Island treatment facility, as well as at the satellite stations. The database features a scheduler that tracks the time from last recorded maintenance to the next scheduled maintenance for every piece of equipment. Work orders are generated through the database and issued to maintenance crews. MP2 does not currently support run-time tracking, so these schedules are time-based. Lowell is aware of the best practice of run-time based maintenance actions and is actively exploring options for improved CMMS software packages. However, current funding is not sufficient to support an upgrade to the CMMS at this time.

Lowell Wastewater also maintains a full-time crew for each of a vacuum truck and a video-inspection truck, which are deployed on a regular schedule for catch-basin cleaning and video inspection of the sewer system. This program is run in close coordination with City Engineers to clean and investigate the sewer and drain systems in advance of the City's paving schedule in order to identify and complete repair needs prior to new paving projects. Otherwise, the crews are deployed to other priority sections of the collection system to inspect, clean and identify repair needs.

Vehicle and heavy equipment maintenance is performed regularly, as well, and is tracked by the Maintenance Division. Fleet vehicle maintenance is coordinated with the DPW garage.

3.3.1 Maintenance Budgeting

The maintenance budget is coordinated annually by the division managers and the Executive Director. The fiscal year 2021 operating budget for Lowell Wastewater was \$20.1 M. The maintenance budget comprised 25% of the total, or \$5.0 M in FY2021. This budget was allocated toward new sewer repairs, overhead costs, street sweeping and catch-basin cleaning, satellite station maintenance, and GIS support services.

3.3.2 Planned and Unplanned Maintenance

Maintenance actions are planned through the MP2 CMMS, as discussed above. Maintenance personnel actively respond to work-order requests at Duck Island and throughout the collection system. All planned maintenance schedules are designed based on experience operating the particular equipment installed in the collection system. Long-term planning for upgrades includes assessment of critical system equipment nearing its life expectancy and such equipment is upgraded as soon as possible. Unplanned maintenance needs are inevitable, though, and these needs are prioritized as they are identified. Emergency repairs are performed as necessary.

2021 Summary

In 2021 the maintenance division completed 1,350 work orders, including 397 work orders in the collection system. More details are provided in [Section 3.3.3](#), Sewer Cleaning; [Section 3.4.3](#), Sewer System Inspection; and in [Section 3.5](#), Sewer System Rehabilitation.

3.3.3 Sewer Cleaning

Sewer cleaning is performed for the purpose of reducing odor issues, maintaining adequate flow rates to convey sewage, and to prevent buildup and blockage of sewer lines from settled solids, rags, grease and detritus. Lowell owns and operates two vacuum trucks, which are equipped with pressure jet hoses used to break up blockages that are then vacuumed into the truck's holding tank and later emptied into dumpsters at Duck Island. The drainage from these dumpsters flows to the headworks for treatment, in accordance with the treatment facility Multi-Sector General Permit (MSGP) for stormwater management.

The combined sewer system is frequently flushed clean via rainfall – this was one of the perceived benefits of combined systems by the early sanitary engineers who designed them. With the exception of a few poorly sloped lines that are prone to clogging and are cleaned monthly, Lowell's sewer cleaning program is able to focus on cleaning the sewer and drain lines in coordination with the City paving program.

In the event that cleaning requirements are identified that exceed the equipment capacity, Lowell Wastewater contracts for heavy cleaning services.

Summary of Sewer Cleaning Activities in 2021

Cleaning activities for the year in 2021 included: catch-basin cleaning (297 combined-sewer and 243 municipal drainage catch basins were cleaned, removing 337.5 tons of debris), sewer line cleaning (9,365 feet of sewer and drain line were cleaned), and street sweeping, which is conducted twice annually (341.8 tons of debris were prevented from entering the collection systems).

3.3.4 Parts and Equipment Inventory

Lowell Wastewater employs a full-time Parts and Equipment Manager, who works with the CMMS Administrator to track and maintain adequate supplies in the stock room to meet planned maintenance needs, as well as extra stock for unplanned maintenance. This inventory is managed in parallel with the MP2 CMMS system previously discussed.

3.4 Sewer System Capacity Evaluation – Inspection

The capacity of the sewer system is assessed on a recurring basis. Assessment efforts include: video inspection of the sewer system; flow-monitoring programs in support of collection-system model development, conductance surveys throughout the interceptor system to identify and further investigate parts of the system with low conductance suggestive of high inflow. The remainder of this section discusses each of these methods of capacity evaluation in more detail.

3.4.1 Flow Monitoring

Lowell has installed permanent level sensors at CSO regulators and upstream of interceptor flow-control gates. These sensors are essential to the automated high-flow management (HFM) procedures discussed in [Section 2.3](#) of this report, and for measurement and reporting of CSO diversion volumes. Regular review of data collected via these sensors occurs in the bi-weekly HFM meetings, providing a regular checkpoint to ascertain system capacity in the context of wet-weather events.

3.4.2 Level Sensor Monitoring

Lowell has a collection of ADS ECHO level sensors deployed strategically in areas throughout the city to observe real-time flow levels passing through its collection system. These level sensors measure and collect level profiles over user-specified time intervals across an established deployment period. Data collected from these sensors is transmitted to an online viewing portal using the LTE-M network and a 4G SIM connection that have been designed and optimized for the Industrial Internet of Things (IIoT). These sensors utilize an advanced mounting feature that secures sensor alignment near the top of the manhole, allowing for quick deployment and easy maintenance. This method of secured mounting assures that consistent, high-quality data is being collected, while eliminating the likelihood of false alarms due to sensor disruption. Text and email alerts can be set such that an alert notification is sent out in real time when a set level threshold is breached. This “alarm level” is set to match the pipe crown height relative to the manhole floor depth from rim.

Lowell began to utilize four level sensors for targeted flow monitoring at various locations in the collection system with known surcharging issues. These sensors were typically deployed at, or just downstream of, a manhole experiencing repeated surcharge overflows; in select instances, namely by the location of the proposed Pevey Storage Facility and Marginal Street bypass line, multiple sensors were deployed together in sequence to better characterize how pipe capacity affected downstream surcharging. Sensors were continuously deployed and inspected both before and after heavy rain events. The data collected by these sensors provides for a better understanding of the duration and intensity of any captured surcharge and enables for a quicker real-time response from Lowell Wastewater to investigate, remediate and resolve surcharging issues as they happen.

Implementation of these ECHO level sensors was later expanded in 2021 to incorporate a more proactive approach aimed at alleviating areas of the city of street flooding. With the purchase of two additional units, and signal service upgrades being made to the existing units, all of Lowell’s ECHO sensors are equipped for more accurate and responsive real-time reporting of live data.

The process is as follows: Lowell Wastewater is notified of an active collection system performance issue (e.g. sewer surcharging and/or street flooding); responding personnel attempt to resolve the issue upon initial response and monitor the area for recurring problems; upon the discovery of a repeated issue, the impacted area is thoroughly investigated via video inspection; if no immediate issues are identified during this inspection, an ADS ECHO level sensor is deployed in the nearest downstream manhole to the impacted area; data is routinely collected over a scheduled deployment period to understand the baseline and peak level conditions at the area of concern; the data is transmitted to an online dashboard and analyzed and used to support the development of a solution that best utilizes existing system capacity, as necessary and when possible, to resolve the reoccurring issues; modifications to the collection system are made (e.g. a leaching basin and overflow to the sewer is installed, a pipe is cleaned and lined) and the level sensor is redeployed for post-remedial monitoring to verify that the solution is adequate in resolving the issue. Once it is apparent that any issues have been resolved without adverse impact to the collection system, the ADS ECHO level sensor is relocated to the next area of concern.

Summary of Level Monitoring Actions in 2021

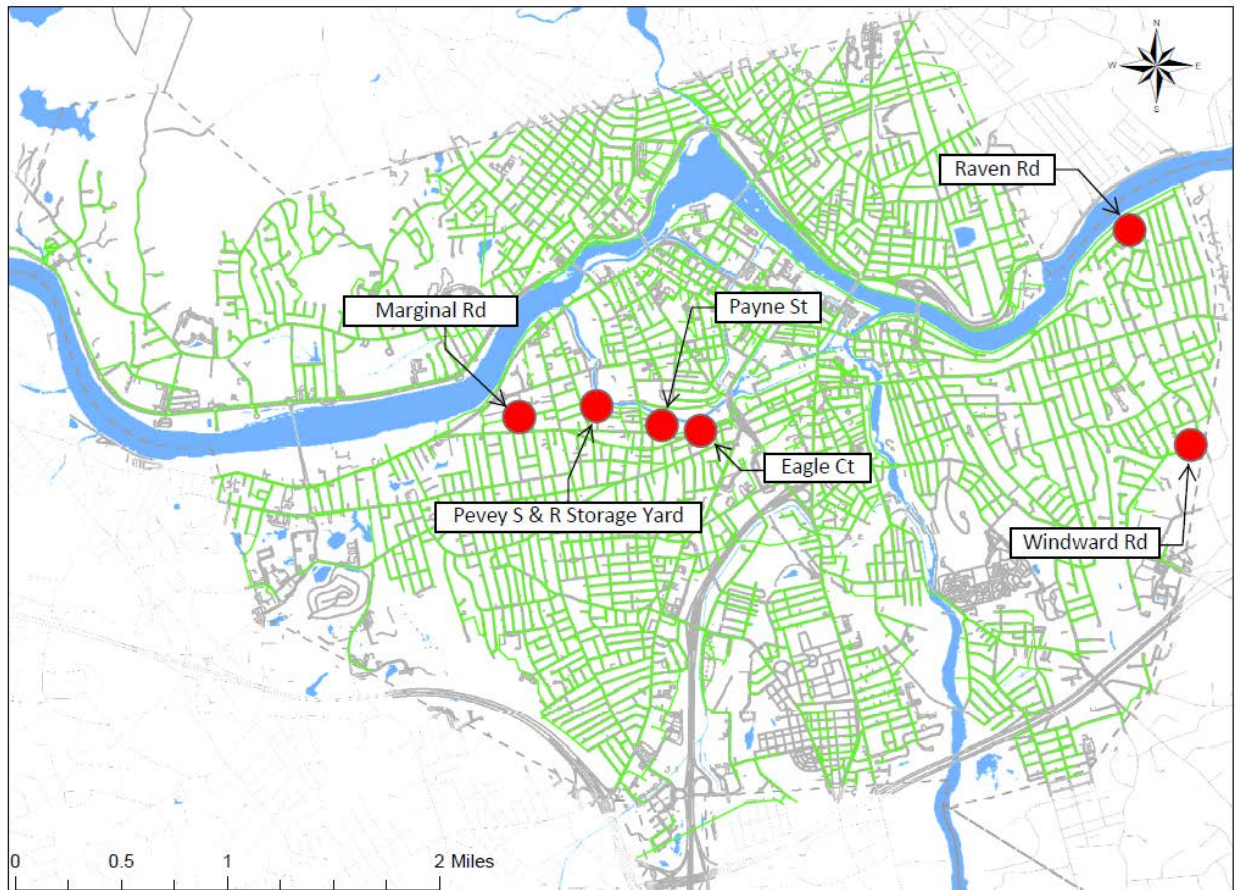
Figure 3-3 shows a topographical overview of where Lowell had deployed ADS ECHO level sensors in its collection system of the course of 2021. Monitoring locations include: Raven Road, Payne Street, Pevey S and R Storage Yard, Eagle Court, Windward Road, and Marginal Street.

A summary of these monitoring results is provided in *Table 3-1* below:

Table 3-1. 2021 Level Monitoring Summary

Location	Deployment Range	Model Type	Monitoring Status
Raven Road	3/31/21 – Present	9000-ECHO-4VZ	Post Remedial Monitoring
Payne Street	9/7/21 – Present	9000-ECHO	Active Monitoring
Pevey S and R Storage Yard	8/13/20 – 3/5/21	9000-ECHO	Removed
Eagle Court	9/22/20 – Present	9000-ECHO-4VZ	Active Monitoring
Windward Road	8/13/20 - Present	9000-ECHO	Active Monitoring
Marginal Street	8/14/20 – 10/7/21	9000-ECHO	Removed

Figure 3-3. 2021 Level Sensor Locations



3.4.3 Sewer System Conductance Monitoring

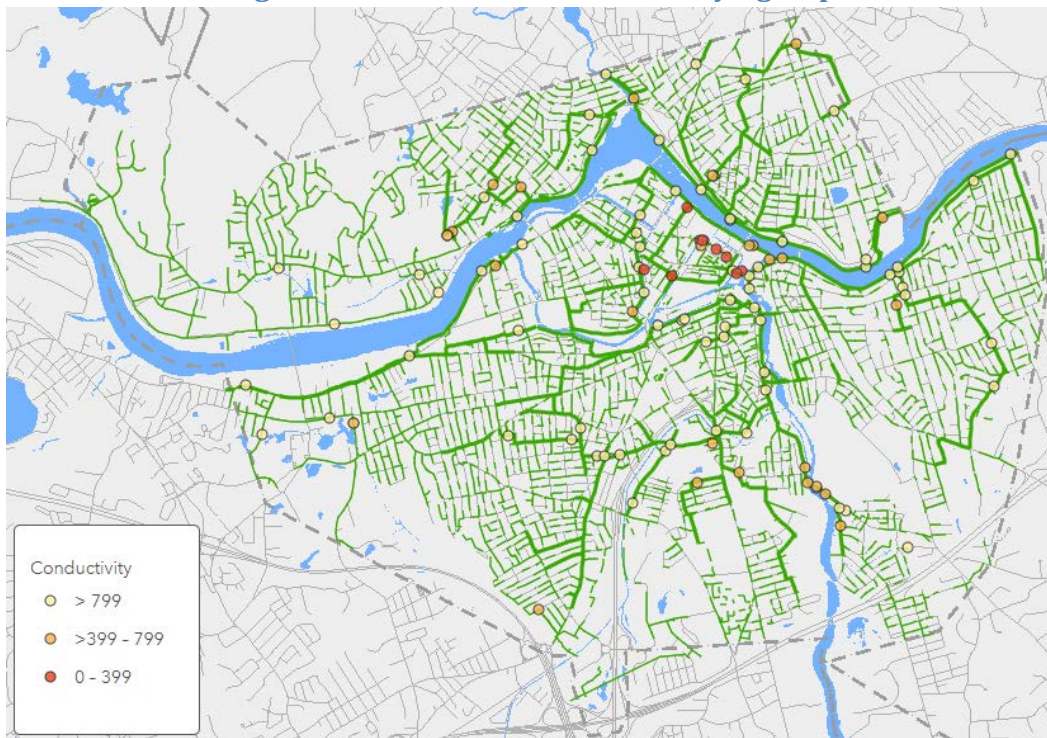
As discussed in [Section 2.8.4](#), Lowell has developed an infiltration and inflow (I/I) monitoring program involving regular conductance surveys to identify areas of flow with low conductivity indicative of non-sewage inflows to the collection system. This program serves as a low-cost, low-manpower means of identifying major I/I sources in the collection system.

2021 Sewer System Conductance Monitoring

A full high-water baseline survey of the collection system was completed in summer 2021. [Figure 3-4](#) shows the results of this monitoring effort. Looking at these results, downtown Lowell had the most high priority values in relatively close proximity, prompting further investigation of the area's collection system.

Through this effort, Lowell Wastewater identified a major source of I/I entering into a 36-ductile iron sewer line submerged under the Eastern Canal, near Kearney Square. A conductivity value taken from the immediate downstream manhole was identified as 395 $\mu\text{S}/\text{cm}$; this was found to be 470 $\mu\text{S}/\text{cm}$ lower than a sample collected immediately upstream, indicating that canal water was making its way into the collection system between these two points. Video inspection quickly confirmed that a large hole had eroded through the pipe's side wall, letting in substantial I/I at a steady flow rate of around 0.5 MGD. With the problem identified and located, Lowell Wastewater employed the help of a consultant to design a pipe sleeve that is scheduled to be inserted in 2022, effectively removing this source of I/I from the collection system.

Figure 3-4. 2021 Conductance Surveying Map



3.4.4 Sewer System Inspection

The video inspection crew performs inspection of the collection system lines continuously throughout the year. Inspections are coordinated through the bi-weekly collection system meetings previously discussed, at which City Engineers and Lowell Wastewater program managers coordinate drinking water, drainage system, and sewer system repairs with City paving projects in order to minimize the frequency of construction-related impacts on Lowell citizens. The City imposes a five-year moratorium on issuance of street-opening permits following paving, so it is imperative that Lowell Wastewater investigates and makes the appropriate repairs to all infrastructures within any street that is on the list to be paved. Additionally, the video inspection truck is deployed to other priority sections of the collection system through the submission and receipt of inspection requests on an as-needed basis.

Inspection reports are generated using software on the video truck, and these reports are reviewed during the bi-weekly collection system meetings to identify all sewers and drains that require rehabilitation. These are added to the prioritized list to be lined, repaired or replaced. Repair and replacement methods are discussed further in the next section.

Summary of Sewer System Inspection Activities in 2021

Approximately 104,200 feet of sewer and drain line were inspected in 2021, which informed the generation of work orders for cleaning, repair and replacement at locations throughout the collection system.

3.5 Sewer System Rehabilitation

As has been discussed above, rehabilitation is by necessity closely coordinated with the City's street paving program due to the City's mandatory 5-year moratorium on issuance of street-opening permits following new paving.

Following inspection and prioritization of rehabilitation needs throughout the collection system, a proper rehabilitation method is determined based on the existing condition of the structures in need of repair. Where possible, a repair method such as lining or grouting is selected over replacement. Where existing conditions are such that lining or grouting would not appreciably extend the life expectancy of the asset, the asset is scheduled for replacement.

3.5.1 Excavation and Replacement

Replacement projects are contracted to a third-party specialist who then conducts the required work at the direction of the Collection System Supervisor. This dig-and-replace alternative is, of course the best option for meeting the objective of improving the overall quality of the repair, but it is also the most expensive. Often, the estimated scope of the repair required changes after exposing the compromised piping, sometimes requiring additional repairs. All such work is performed according to standards and specifications required by the City Engineer.

3.5.2 Cured-In-Place-Pipe Lining

Cured-in-place-pipe (CIPP) lining is an industry-accepted practice for the repair of sewer lines that are not structurally damaged to the point of needing full replacement but suffer from extensive deficiencies

leading to infiltration and structural vulnerability. CIPP lining is a relatively inexpensive method of repairing such sewer lines, wherein an epoxy-impregnated tube of fabric is inserted into the damaged pipe (after cleaning the pipe), and the epoxy is then activated with steam. The tube then hardens as the epoxy cures to a structural rigidity similar to poly-vinyl-chloride (PVC) pipe.

3.6 Summary of Collection System Maintenance in 2021

The following figure and table present a map and log of typical collection system sewer repairs and replacements undertaken in 2021. In total, \$5M was allocated from the FY 2021 budget and invested into the collection system repair and maintenance. These projects include: 351 feet of new sewer pipe installed; 2,317 feet of cured-in-place-pipe repairs; repair and replacement of 91 catch basins; repair and replacement of 16 manholes. Also included in this total are 339 feet of replaced drainage; 540 sewer and drainage system catch-basins cleaned; and associated miscellaneous items like test pits, paving and sidewalk repairs. An interactive version of this map *containing information specific to each repair* can be accessed online via the following link: <https://arcg.is/KKian>.

Figure 3-5 2021 CMOM Work Map

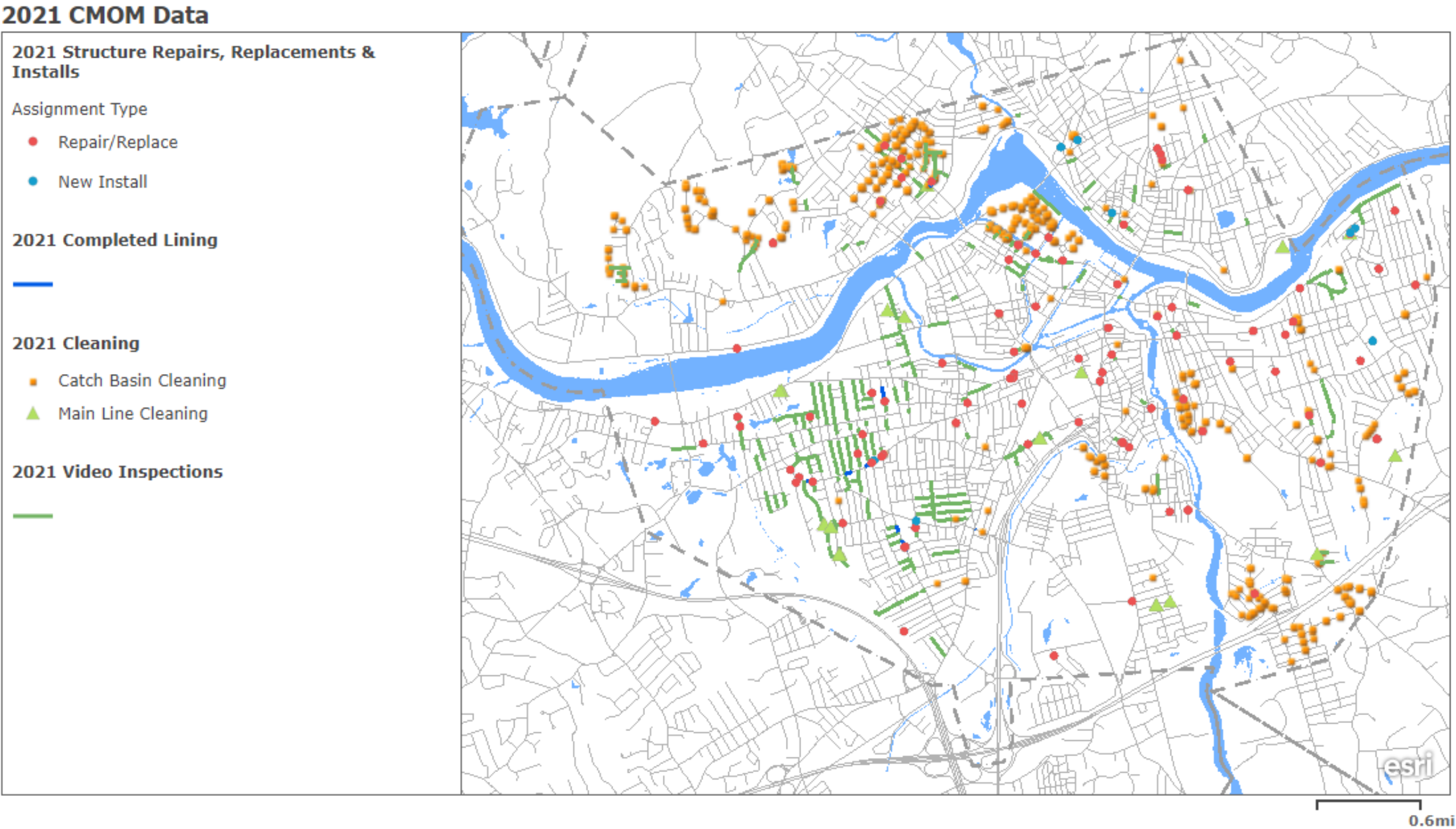


Table 3-2 2021 CMOM Work Log

Work Done	Facility ID	Street	Repair Cost	Repaired Date
Sewer Lining	SMH-007676-SMH-007675	Stevens St.	\$203,522.82	5/10/2021
Sewer Lining	SMH-007674-SMH-001197	Stevens St.		5/24/2021
Sewer Lining	SMH-001197-SMH-007657	Stevens St.		5/24/2021
Sewer Lining	SMH-005403-SMH-005420	1852 Middlesex St.		6/1/2021
Sewer Lining	SMH-000068-SMH-000069	422 Pine St.		6/1/2021
Sewer Lining	SMH-000003	121 Pine St.		6/2/2021
Sewer Lining	SMH-000332-SMH-007674	Stevens St.		6/3/2021
Sewer Lining	SMH-001124-SMH-001123	198 Pine St.		6/16/2021
Sewer Lining	SMH-001124	208 Pine St.		6/16/2021
Sewer Lining	SMH-007676-SMH-007675	Stevens St.		6/17/2021
Sewer Lining	SMH-001143-SMH-001142	240 Pine St.		6/21/2021
Sewer Lining	SMH-001142	226 Pine St.		6/21/2021
Sewer Lining	SMH-000631-SMH-000632	305 Pine St.		6/23/2021
Sewer Lining	SMH-001710-SMH-001712	Plain St.		6/23/2021
Sewer Lining	SMH-007398-SMH-007294	University Ave.		9/28/2021
Repair	SMH-002311	S. Highland St.	\$3,213.00	3/24/2021
Repair	DMH-000296	Fairgrove St.		3/30/2021
Replace	Unmapped-CB	13th St.		5/3/2021
Repair	Sewer Service	E. Merrimack St	\$2,394.37	5/4/2021
Repair	CB-007912	Andover St.		5/6/2021
Repair	BMH-001125	223 Pine St.		5/7/2021
Repair	SMH-001197	Stevens St.		5/10/2021
Repair	DMH-008069	Stevens St.		5/10/2021

Work Done	Facility ID	Street	Repair Cost	Repaired Date
Repair	DMH-008067	Stevens St.		5/10/2021
Repair	Unmapped-CB	153 Hale St.		5/11/2021
Replace	SMH-003696	Grand St.		5/11/2021
Repair	CB-011790	Middlesex St.		5/11/2021
Repair	Unmapped-CB	111 Douglas Rd.		5/13/2021
Repair	Unmapped-CB	Guild St.		5/13/2021
Repair	CB-010104	Wentworth Ave.		5/13/2021
Repair	CB-012305	28 State St.		5/13/2021
Replace	SMH-003754	607 Dutton St		5/13/2021
Repair	CB-010755	University Ave.		5/13/2021
Repair	CB-005180	Fairmount St		5/13/2021
Repair	Unmapped-Manhole	Gorham St.		5/13/2021
Repair	Unmapped-CB	Hall St.		5/13/2021
Repair	CB-010652	Stevens St.		5/13/2021
Repair	CB-009095	Freedom Way.		5/13/2021
Repair	CB-013194	Pine St.		5/14/2021
Repair	Unmapped-CB	Pine St.		5/14/2021
Repair	SMH-000169-BMH-000045	Westview St.	\$6,257.14	5/17/2021
Repair	CB-013192	Pine St.		5/18/2021
Repair	CB-011874	Pine St.		5/18/2021
Repair	CB-009676	E. Merrimack St.		5/20/2021
Repair	SMH-007802	704 Wilder St.		5/20/2021
Repair	CB-013595	Middlesex St.		5/20/2021
Replace	Unmapped-CB	Merrimack St.	\$2,394.37	5/21/2021
Repair	SMH-007664	Parker St.		5/25/2021
Repair	CB-010654	Pine St.		5/26/2021
Replace	CB-012933	Union St.		5/26/2021
Replace	Unmapped-CB	Kinsman St.		5/27/2021
Replace	Unmapped-CB	Belmont St.		5/28/2021
Replace	CB-013122	Suffolk St.	\$7,265.00	5/28/2021
Replace	DMH-002486	512 Douglas Rd.		6/14/2021
Repair	SMH-002830	Dummer St.	\$750.00	6/17/2021
Replace	SMH-003408	Queen St.	\$25,765.58	6/17/2021
Repair	CB-004136	French St.	\$600.00	6/18/2021
Replace	CB-001011	Stevens St.	\$7,564.06	6/18/2021
Repair	DMH-007600-D-OUT-000225	Upham St.	\$27,666.45	6/21/2021
New Install	Sewer Main	Dalton Ct.	\$73,137.40	6/24/2021
Replace	CB-010164	Westford St.		6/25/2021
Repair	Sewer Service	Central St		8/2/2021

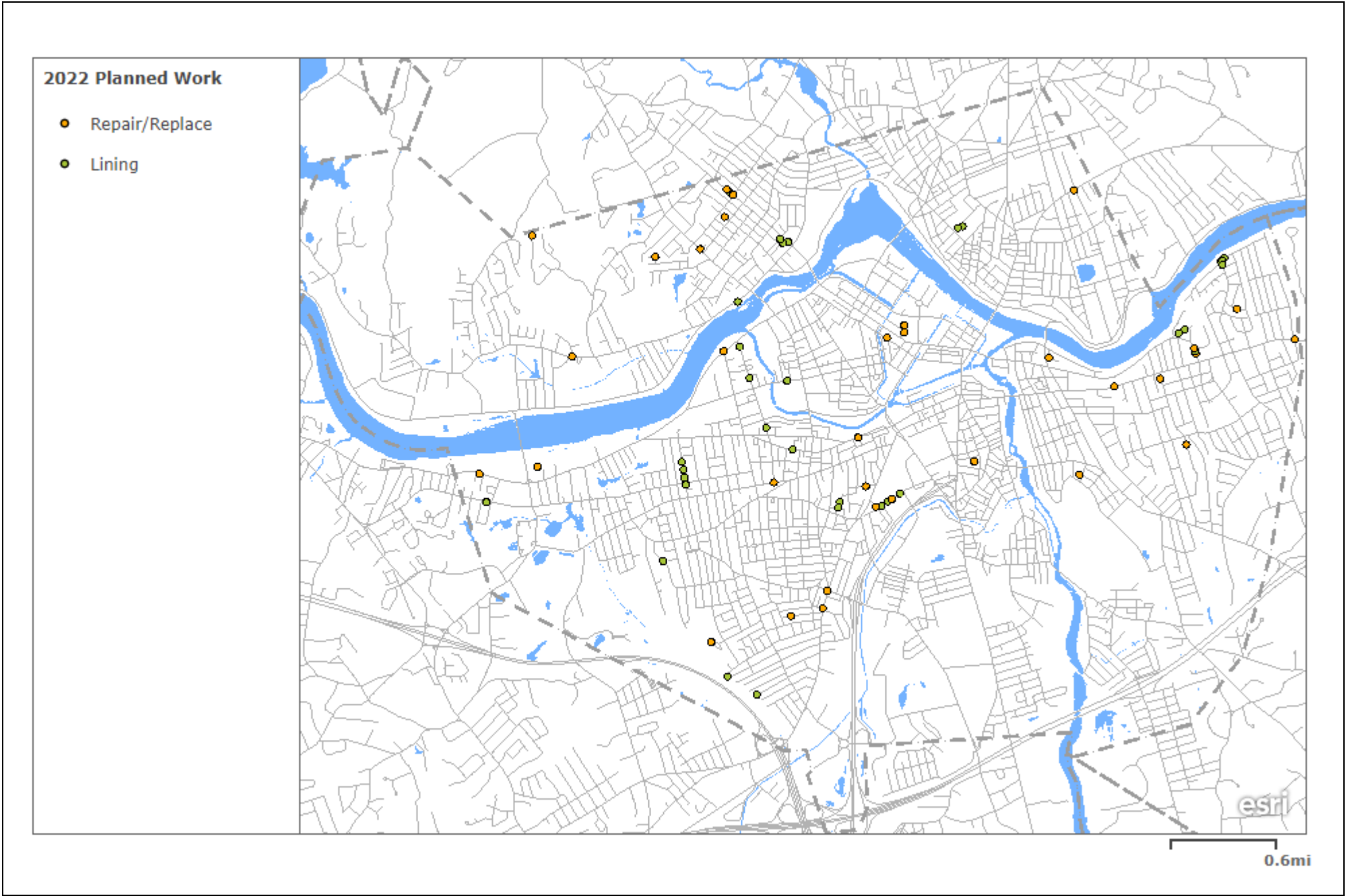
Work Done	Facility ID	Street	Repair Cost	Repaired Date
Replace	SMH-002274	Crosby St		8/4/2021
Replace	CB-012332	Crosby St.		8/4/2021
Replace	CB-012331	Crosby St.		8/4/2021
Repair	CB-012243	High St.		8/4/2021
Repair	Sewer Service	University Ave.	\$3,388.55	9/20/2021
Replace	SMH-003213	W. Third St.		9/20/2021
New Install	New CB	Island St	\$8,599.38	9/21/2021
Repair	SMH-007292	Gershom Ave.		9/21/2021
New Install	New CB	Tiffany Dr.	\$16,197.12	9/22/2021
Repair	SMH-006007-SMH-006006	Wentworth St.		9/22/2021
Replace	CB-008883	Florence Rd.	\$7,290.90	9/24/2021
Replace	CB-009844	Rogers St.	\$7,682.34	9/27/2021
Replace	SMH-005844	Winding Ln.		9/27/2021
Replace	SMH-006215	Trull Ln.	\$600.00	9/28/2021
Repair	CB-012156	Concord St.	\$600.00	9/28/2021
Repair	CB-012213	Fayette St.	\$750.00	9/28/2021
Repair	CB-012053	Andover St.	\$1,102.50	9/28/2021
Repair	CB-011197	Father Morissette Blvd.	\$1,200.00	9/28/2021
Repair	CB-010783	Fletcher St.	\$1,202.25	9/28/2021
Repair	Unmapped-CB	Wachusett St.	\$750.00	9/28/2021
Repair	Unmapped-CB	Wachusett St.	\$1,702.50	9/28/2021
Replace	Unmapped-CB	Appleton St.	\$7,621.65	9/29/2021
Replace	CB-013284	Middlesex St	\$8,043.77	9/29/2021
Repair	SMH-004713	Pevey St.	\$21,344.14	10/1/2021
Replace	CB-008709	Father Morissette Blvd	\$13,588.93	10/5/2021
Replace	CB-011395	Woburn St.		10/5/2021
Repair	Sewer Service	Depot Ave.		10/8/2021
Repair	Unmapped-CB	Bigelow St.	\$600.00	10/8/2021
Repair	DMH-005204	Park Ave. W.		11/15/2021
Replace	DMH-002486	Douglas Rd.		11/18/2021
Replace	CB-012308	Agawam St.		11/19/2021
Replace	CB-011932	Rogers St.		11/19/2021
Replace	CB-003733	Middlesex St		11/19/2021
Repair	SMH-007570	Baldwin St.		11/19/2021
Repair	SMH-007569	Baldwin St.		11/19/2021
Replace	CB-012811	Tenth St.		11/19/2021
Replace	Unmapped-CB	Fourth Ave.		11/22/2021
Replace	CB-009766	Fetherston St.		11/22/2021

Work Done	Facility ID	Street	Repair Cost	Repaired Date
Repair	SMH-001070-SMH-001013	Canton St.		11/22/2021
Repair	Unmapped-CB	Mt Grove St.		11/24/2021
Replace	Unmapped-CB	Spencer St.		11/24/2021
Repair	CB-011626	Pawtucket Blvd.		11/24/2021
Repair	CB-010057	Starr Ave.		11/24/2021
Repair	CB-009374	Cornell St.		11/24/2021
Repair	SMH-000371	W. Meadow Rd.		11/29/2021
New Install	New CB	Roberta Lane		11/30/2021
New Install	New CB	Fulton St.		12/1/2021
Repair	CB-010007	School St.		12/1/2021
New Install	New CB	Winding Ln.		12/2/2021

3.7 Planned Collection System Investigation/Action in 2021

As previously mentioned throughout this report (specifically in [Section 3.3](#)), Lowell Wastewater plans system investigation and maintenance activities following the City’s paving schedule in order to identify and complete sewer repairs ahead of new paving projects, ensuring compliance with the City’s self-imposed five-year moratorium on street openings following repaving. [Figure 3-6](#) below contains a map showing pre-identified areas of for planned collection system maintenance and lining projects to be completed in 2022.

Figure 3-6 2021 CMOM Investigation/Action Areas



4. References

Hazen. (2019). *Integrated Capital Plan*. Boston, MA.

MassDEP. (2017). *Guidelines for Performing Infiltration/Inflow Analyses and Sewer System Evaluation Surveys*. Wilmington, MA: Commonwealth of Massachusetts.

US EPA. (2019). *Sewer System Compliance Inspection Report*. Boston, MA.